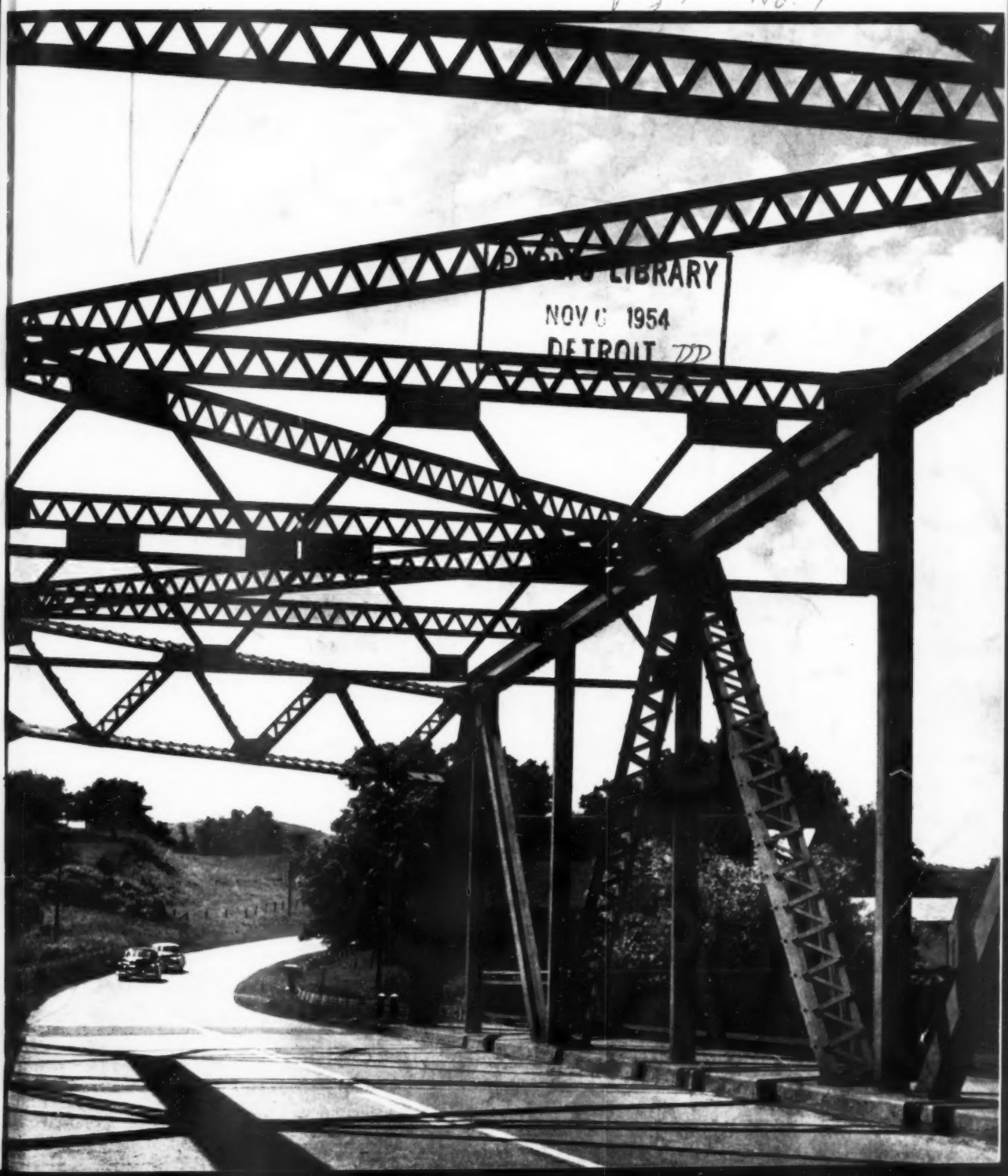
TECHNOLOGY DEPT.

TECHNOLOGY REVIEW

November 1954

V 57 No. 1



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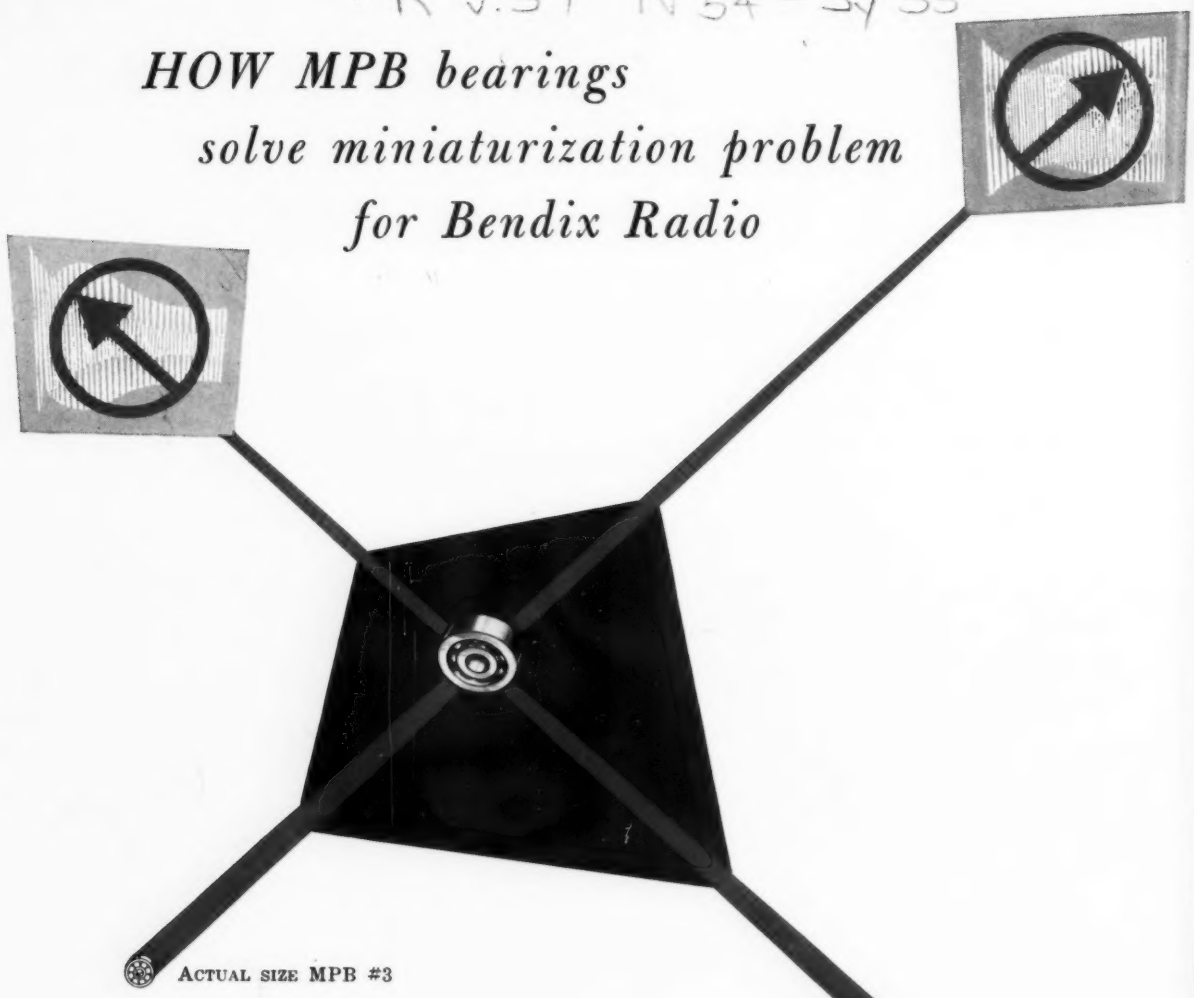
HOW MPB bearings solve miniaturization problem for Bendix Radio



ACTUAL SIZE MPB #3

MPB ball bearing used as Index Pawl in miniature frequency selector switch

OPERATING CONDITIONS — miniature ball bearing serves as index pawl in 4-position indexing device . . . bearing travels at 936 r.p.m. CRITICAL — low starting torque, low friction rotation . . . high impact loads . . . long, trouble-free bearing life. RESOLVED — by use of MPB No. 3, .1875" o.d. full-race bearing.

To quote Mr. John F. Wroten, Jr., mechanical engineer with Bendix Radio Division, these are some of the reasons why MPB bearings were selected in the miniaturization of their frequency selector switch: "The low friction rotation of the bearing practically eliminates drag in the indexing action, and reduces to a minimum the amount of power required for disengagement. Also, the bearing displays unusually high resistance to the frequent impact loads a detent stop of this kind must withstand . . . . Because rolling contact occurs between the pawl and the plate, the plate can be made of soft stainless steel."

For problems involving miniaturization, consult MPB, pioneer manufacturer of miniature ball bearings.

Miniature *Precision* Bearings, Inc., 103 Carpenter St., Keene, N. H.

MPB

Tech

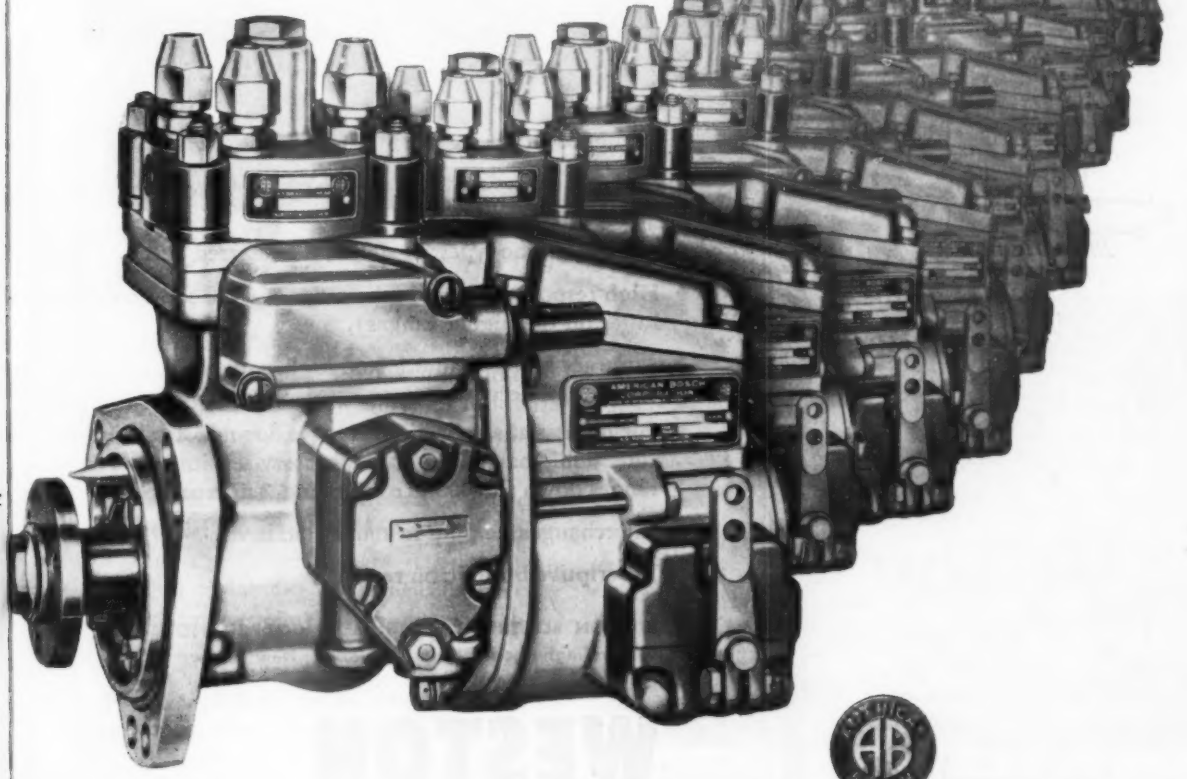
over 60,000 . . . and STILL GROWING

Over 60,000 American Bosch PSB single-plunger distributor-type Diesel fuel injection pumps have been produced since the pump was introduced several years ago.

Today, this simplified, lower-cost pump is being produced at a greater rate than ever before.

Here's definite proof of the acceptance of the PSB. It has literally revolutionized the concepts of fuel injection and made possible smaller, lower-cost Diesel engines . . . opening up new markets for Diesel power such as the farm tractor.

Tried and proved in the severest service, the PSB has rolled up remarkable records of performance—requires less maintenance—is easily serviced in the field. No wonder it has been hailed throughout the industry for its great contribution to Diesel progress.
American Bosch Corporation, Springfield 7, Mass.



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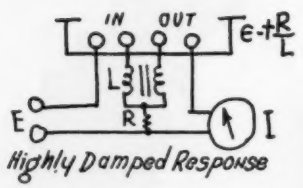
AMERICAN BOSCH

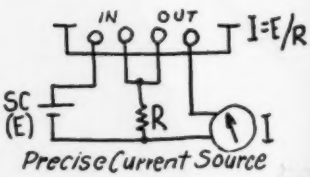
THE TECHNOLOGY REVIEW, November, 1954, Newsstand Edition. Vol. LVII, No. 1. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $4.00. Canadian and Foreign subscription, $4.50. Entered as second-class matter December 23, 1949, at the Post Office at Bristol, Conn., under the Act of March 3, 1879.

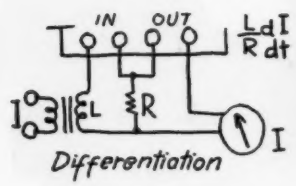
Weston Model 1411

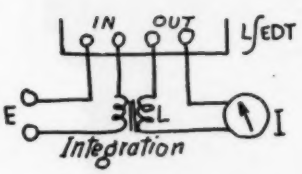
D-C INSTRUMENT AMPLIFIER

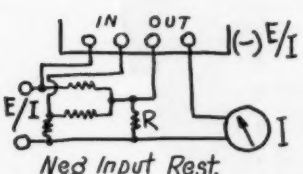
SPECIAL APPLICATION SCHEMATICS

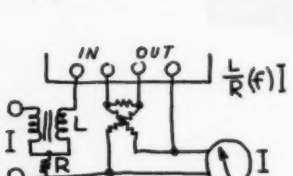


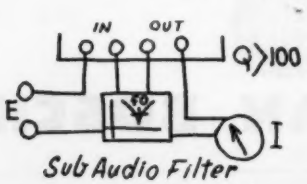












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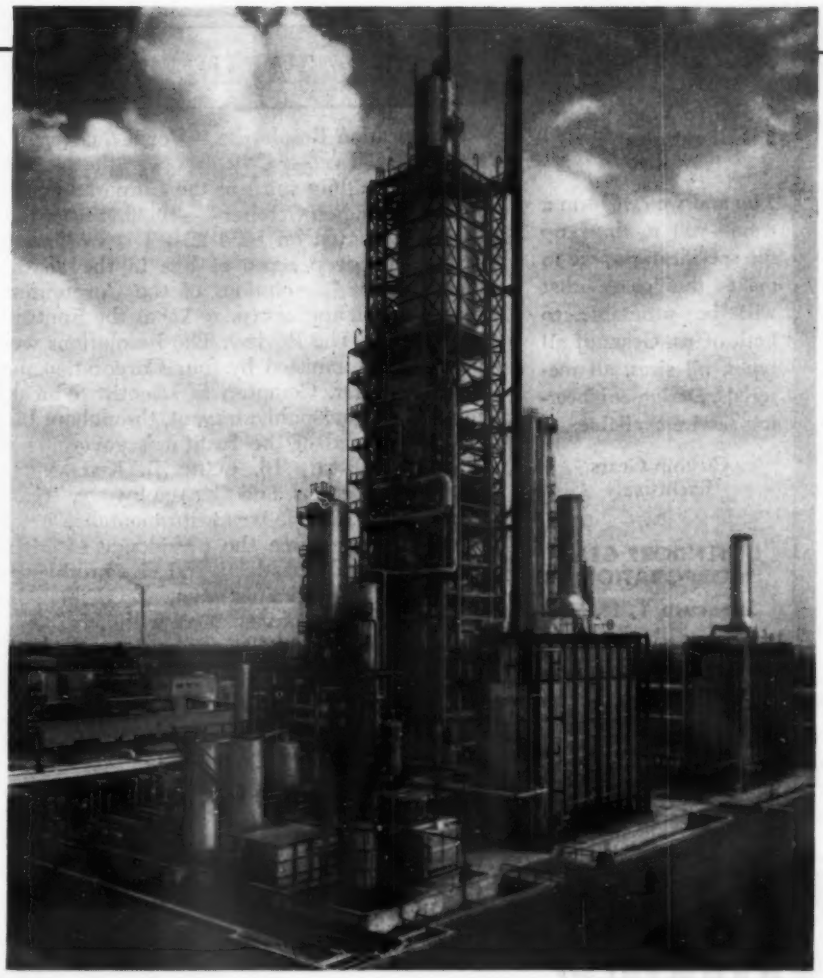

The new Condor catalytic cracking unit has a capacity of 15,000 barrels per day. The crude unit in the background has a capacity of approximately 45,000 barrels. Condor's new gas plant and compressor building are shown below.

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Located in the Po River Valley, and advantageously situated in relation to Italy's fine Autostrade highway system, "Condor S.p.A. L'Industria Petrolifera e Chimica," exemplifies the regeneration of Western Europe's essential industries.

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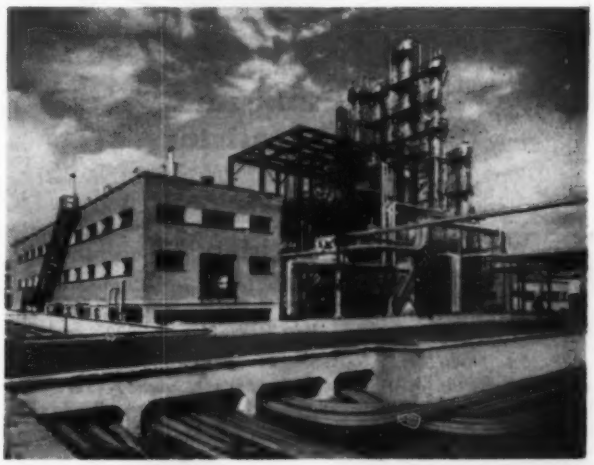
Write or call us for information as to how our experience may be of assistance to you.



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THE TABULAR VIEW

Corporation Resolution. – For a quarter of a century, KARL TAYLOR COMPTON was the presiding officer and guiding spirit of the Corporation of M.I.T. At its meeting on October 4 – the first since the death of Dr. Compton on June 22 – The Corporation expressed its deep sense of loss in the death of its chairman, in "Resolutions of the Corporation," the text of which appears (page 12) as the frontispiece of this issue of The Review. The Resolutions were prepared and submitted by four Corporation members who knew Dr. Compton as scientist, educator, administrator, and public servant, throughout his entire period as head of the Institute's governing body – VANNEVAR BUSH, '16, JAMES R. KILLIAN, JR., '26, ALFRED L. LOOMIS, and GERARD SWOPE, '95. In large measure, Dr. Swope was instrumental in getting Dr. Compton to assume the presidency of M.I.T. Dr. Bush was professor, dean, and vice-president during Dr. Compton's administration. Dr. Killian has had long and intimate association with Dr. Compton in the Institute's many administrative problems and succeeded him as president in 1949. Dr. Loomis has often worked closely with Dr. Compton, especially during World War II when M.I.T. was responsible for the Radiation Laboratory.

Desalting the Oceans. – With something like three-quarters of the earth's surface covered by water, it may come as a surprise to many that man could face the serious problem of water shortage. Home and industrial uses of water have expanded greatly in the past half century, and the world's population continues on its upward trend. Before ocean water can be made serviceable for most uses, its salt must be removed economically. A survey of present-day methods of purifying water, and an estimate of the cost involved in each case is presented (page 15) in an article by THOMAS K. SHERWOOD, '24, Professor of Chemical Engineering and, from 1946 to 1952, Dean of the School of Engineering at M.I.T. Dr. Sherwood's stimulating article was presented before the Society of Arts at the Institute last spring.

Process of Aging. – As a sequel to his article in the May, 1954, issue of The Review ("Is There a Limit to Human Life?") JAMES A. TOBEY, '15, discusses "The Process of Aging" in this issue (page 21). The topic is of interest to social scientists and administrators for the problem it creates as the average age of the nation's population continues in its upward course. But it is of interest to the individual as a means of indicating how certain baleful effects of life's inevitable onward march can be minimized or alleviated, and in developing the art of aging gracefully and graciously. Dr. Tobey has four degrees, a colonelcy, at least one book, and many magazine articles to his credit.

Russian Air Power. – In an article whose main purpose may be said to be that of cautioning against over-optimism, JACK W. RIZIKA, '47, reviews prog-

(*Concluded on page 6*)

MOLYBDIC OXIDE

—a versatile intermediate

Molybdic oxide, MoO_3, is the intermediate for the synthesis of a large family of molybdenum chemicals.

MoO_2Cl_2 $MoO(OH)_2Cl_2$

These oxychlorides are volatile, soluble in water and organic solvents, and chemically reactive. MoO_2Cl_2 is obtained by the action of chlorine on the dioxide or trioxide, $MoO(OH)_2Cl_2$ by hydrogen chloride on the trioxide.

R_2MoO_4

The soluble alkali and ammonium molybdates are prepared by dissolving the oxide in the appropriate base. Insoluble molybdates are formed by precipitation or calcination.

MoO_2

The dioxide is insoluble, infusible, involatile, and rather inert chemically. It is obtained by reduction.

ORGANIC COMPLEXES

Soluble complexes are formed with many hydroxy and dibasic acids, and with polyhydric phenols.

$R_2O(MoO_3)_n$

Polymolybdates are known where n is 1, 2, 3, 4, 6, 8, 10 and 16.

R_2MoO_{4+n}

Permolybdates with values of n of 1, 2, and 4 may be obtained by treating molybdates with hydrogen peroxide.

$(R_2O)_x(XO_y)(MoO_3)_z$

The heteropolymolybdates form an enormous family of high-molecular-weight acids and salts that can be tailor-made to your specifications. X can be almost any element in the periodic table. Most heteropolymolybdates are soluble and are readily formed in acid solution from simple molybdates or molybdic oxide.

Will data on molybdic oxide and its derivatives help your thesis project? Write for our bulletin "Properties of Molybdic Oxide." *Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.*

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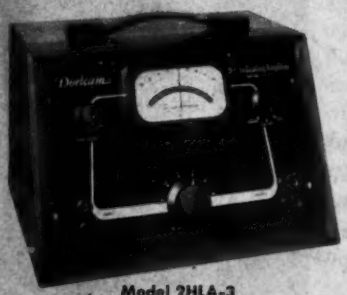
D-C Indicating Amplifier



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Write for Bulletin IA15

The D-C Indicating Amplifier, Model 2HLA-3, is a completely self-contained instrument for amplification and measurement of minute d-c signals. A new design concept utilizing the DOELCAM Second-Harmonic Magnetic Converter as the input stage avoids the limitations of the usual mechanical type converters and results in improved performance.

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THE TABULAR VIEW

(*Concluded from page 4*)

ress in Russian aeronautical technology from World War I to the present time. His article in this issue (page 23) clearly shows the benefits which Russian aeronautical technology derived from research work conducted in Germany during the Hitler regime, and emphasizes the need for evaluating present Soviet air strength in realistic terms. Mr. Rizika received the S.B. and S.M. degrees from M.I.T. in 1947 and 1949, respectively, and continued graduate work at Harvard University between 1949 and 1953. He was project analyst at the Glenn L. Martin Company from 1953 to 1954. At present he is working with a member of the Institute's Department of Mechanical Engineering, and with the Aircraft Gas Turbine Division of General Electric Company.

Place for Gladness. — At its quarter-century reunion at M.I.T. last June, PROFESSOR ERWIN H. SCHELL, '12, in charge of the Course in Business and Engineering Administration, made the principal address at the reunion luncheon of the Class of 1929. Professor Schell's inspiring remarks, "A Place for Gladness," appear on page 27 of this issue of The Review. Since his appointment as assistant professor in 1917, Professor Schell has been a popular and highly respected Faculty member who has maintained close contact with his former students.

Science for Man's Welfare. — In his annual message to the M.I.T. Corporation, JAMES R. KILLIAN, JR., '26, President, warned that patriotic and dramatic service of science in national defense could divert attention from its true character as a humanizing, creative, and spiritual force. A wider recognition and understanding of the beneficent nature of science and of creative intelligence is called for, says President Killian, whose report is summarized on page 29 of this issue.

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What General Electric people are doing . . .

QUIET TUBE

The U.S. Navy Bureau of Ships is interested in anything which would extend the range of its early-warning radar stations. Since a target is identified by distinguishing a pip on a radar screen from smaller, noise-generated irregularities, any reduction in noise would make the pip more discernible.

Our Research Laboratory has been working under Navy sponsorship for the past few years to design a strong, low-noise tube for microwave applications. Such a tube has now been developed, in collaboration with our Tube Department. In this tube noise is reduced by keeping the electrodes extremely close together, thus reducing the transit time the electrons require to travel from cathode to grid. The shorter the transit time, the smaller the noise factor.

The new tube, designated GL-6299, is not a single-frequency device, although it was designed for use at microwave frequencies. In fact, it exhibits improved performance throughout the radio and audio-frequency ranges. For usefulness over a large frequency range, it has been made adaptable for use in circuits of the cavity, parallel-line, or lumped-constant type. Despite its small size, it operates at currents and voltages comparable to those of conventional receiving tubes. It is being marketed by our Tube Department in Schenectady.

MAGNETIC SIGNATURES

Determining the magnetic characteristics of a metal can be a long and tedious business. The usual method requires long calculation, using data gathered from sensitive ballistic galvanometers. But that's been changed.

Our General Engineering Laboratory in Schenectady has developed a device called a D-c Recording Hysteresigraph, which eliminates the hours of laborious measurement and calculation. It traces the magnetic "signature" of a metal directly onto a scaled chart in a matter of minutes. It is able to do this with the use of two fluxmeters, which integrate the flux voltage continuously.

The new instrument is expected to be a valuable quality-control device for manufacturers of special steel. Laboratories can also make use of it in obtaining accurate data on commercially-available materials and in the development of new alloys.

LIFE PREDICTER

The conventional way of finding out how long a fluorescent lamp will burn before it fails is to let it burn until it fails. But now the engineers of our Lamp Division at Nela Park, Cleveland, can make a pretty good prediction beforehand.

Other things being equal, they find, the life of a fluorescent lamp is proportional to the amount of emission coating on the cathode. By weighing this emission coating, the life of the lamp can be estimated.

Our engineers at Nela Park have developed a rapid method of testing such lamps for the quantity of chemical on their cathodes without breaking open or lighting the tubes. The lamp is compared in an electronic circuit with one having an uncoated cathode. When current is applied, the coated cathode is slower to increase in temperature. The difference is roughly proportional to the weight of the emission coating, and it can be read on a meter.

RADIOACTIVE SILICONES

Our Silicone Products Department in Waterford, New York, recently made joint announcement with Abbott Laboratories of North Chicago, Illinois, of an Abbott Laboratories project making radioactive silicones available for medicine and industry. Such silicones may prove to be a valuable research tool in certain areas. Radioactive silicone fluids, for example, are made readily measurable in minute amounts by the incorporation of Carbon-14, and they are expected to offer a clearer insight into the behavior of silicones in the human body than could previously be obtained.

The new fluids have been designed for laboratory and clinical test work. They will not be a part of finished medicinals sold to the consumer. In conformity with Atomic Energy Commission practice, such initial studies must be conducted on animals only.

FILM FIXER

What camera fan hasn't spent hours in a darkroom trying to minimize the harmful effects of scratches, dust, or fingerprints on his favorite 35-mm negative? Thanks to Dr. C. Guy Suits, vice president and director of our Research Laboratory, all three of these defects can now be corrected.

Dr. Suits, one of whose hobbies is photography, found that most of the troublesome damage from scratches occurred in the film base or in the gelatine overcoat, rather than in the silver image between. He reasoned that a liquid with the right properties might fill the "valleys" formed by scratches and eliminate the valley side surfaces that scatter light. Although glycerine has been used for this purpose, it is very viscous and forms bubbles.

He finally found the solution in a silicone oil, which has been named Refractasil. Not only did it solve the scratch problem, it also turned out to be a highly satisfactory cleaner, removing fingerprints like magic. And with a special circulating container designed by Dr. Suits, it served to remove dust particles, as well.

Equipment using the Suits technique may soon be marketed by another manufacturer. Refractasil, the silicone oil, is already in production in our Silicone Products Department at Waterford, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Operation "Brain Center"

This room is the control, nerve, or "brain center" of the modern public utility system. From this room control cables carry impulses that operate switches, remote control devices, and telemetering equipment. Here men, by means of remotely-controlled switches, set up and break down circuits. It is here that failures of equipment and outages caused by the elements are circumvented.

All of these operations depend upon the sure and dependable performance of Simplex Control Cables. They must be ready to operate under every conceivable kind of condition. These control cables bear a measure of responsibility entirely out of proportion to their size. But they do it with absolute dependability. The safety of many millions of dollars of public utility equipment rests upon these slender cables and the equipment they control.

Simplex Control Cables are made in three styles: Anhydrex-insulated and neoprene-jacketed, Polyethylene-insulated and Plastex-jacketed, and Plastex-insulated and Plastex-jacketed. There is a size and a style to meet every operating condition on your public utility system, whether it be to operate equipment at a distance, for telephone and communication circuits, for telemetering devices. Whatever the need, be sure that the vital connecting link between the "brain" and the equipment is Simplex Control Cable.

Your local Simplex representative will be glad to help you with any problem you may be facing which has to do with cables.

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Goodyear has produced a new tire—a tubeless tire—the proud successor to every tire you've ever known or heard about.

After years of research that sought a new approach to the tubeless idea, this tire is now a reality—thanks to the development by Goodyear of a new way of treating tire cord—the exclusive and patented 3-T process.

The 3-T process makes the new Goodyear Tubeless Super-Cushion the most efficient air container ever made. It permits a new method of constructing tire bodies. It lets the great new Tubeless Super-Cushion set new standards of tire performance.

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2. **Blowout Protection**—providing a greatly increased margin of safety.
3. **Better Performance**—a quieter, smoother, easier ride—plus even greater mileage than today's great standard tires.
4. **And it combines** all these advantages at a reasonable price . . . no higher than the price of a standard tire and tube.

Perhaps the best proof of these statements is found in the action of the automobile industry. The new Tubeless Super-Cushion will be standard equipment on many of the new 1955 cars.

MORE PEOPLE RIDE ON GOODYEAR TIRES THAN ON ANY OTHER KIND!

Super-Cushion, T. M.—The Goodyear Tire & Rubber Company, Akron 16, Ohio

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EDITED AT

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

C. E. Patch

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KARL TAYLOR COMPTON 1887-1954

President of the Massachusetts Institute of Technology, 1930-1949

Chairman of the Corporation, 1949-1954

RESOLUTIONS OF THE CORPORATION—

Possessed of rare qualities of imagination, perception and understanding, Karl Taylor Compton — as scientist, teacher, educational administrator and devoted public servant—demonstrated throughout his life the power and the good of disinterested creativeness.

In the breadth of its intellectual undertakings, in the forward thrust of its researches and in the spirit of common trust and loyalty pervading its people the Massachusetts Institute of Technology is witness of what his creative force accomplished during the nineteen years of his presidency and the five years of his wise elder statesmanship as Chairman of this Corporation. He found M.I.T. an eminent engineering school; he left it a pre-eminent institute of technology of a new and vital sort. Through his wisdom the Institute was consolidated and stabilized in its traditional endeavors, and through his foresight it was given new motivation and direction that fostered its growth and increased its scope in a crucial period. When he came to M.I.T. it had 3,209 students, 563 on the staff and a budget of $3,739,000. When he died it had 5,183 students, 1,595 on the staff and a budget of $46,181,172. He added a School of Science which has flourished. He encouraged and greatly extended the Institute's program of graduate study, and he engendered a humane and liberal spirit which found many embodiments including a School of Industrial Management and a School of Humanities and Social Studies. The extraordinarily successful Technology Loan Fund and many other aids to students owe their inception to him.

The young men and women who come to M.I.T. for the nurture of mind and spirit are the beneficiaries in manifold ways of his forethought and his vision. None who knew him well will doubt that in the prospering of these young minds he found his greatest reward. Let it be remembered that at nearly the last occasion when he talked with an Institute gathering, he spoke of his own first Commencement, when his father had said to him,"Karl, this is the proudest day of my life." He sought to pass on to his hearers that pride which the older man has in the achievement that the younger man has attained.

For the hallmark of Karl Compton was generosity of spirit, the will to share that which he had, of mind, of spirit, of soul; his great gifts of intellect and comprehension he offered freely and readily wherever there was need. Among his colleagues in faculty, administration and student body he was an example of justice, integrity and candid simplicity. He had a wondrous gift for calling forth the best in other people and for engendering a spirit of good will among all coming within his influence. His personality was free of any trace of guile, a personality emanating goodness and wisdom and always generous and benevolent in human relations. The generosity of spirit which characterized him found natural expression in the friendliness with which he met the world. Throughout the Institute, his associates from the highest to the humblest knew him as a friend, and it is thus that they hold him in their hearts. As our fellow member, Mr. Ferris, has said, "The beauty of his countenance and the expression of his face was clearly an outward sign of inward and spiritual grace."

The record of Karl Compton's accomplishments as scientist, teacher and public servant is large in the history of our age. The Corporation of the Massachusetts Institute of Technology engrosses that record with pride in its annals, and therein sets down with especial honor these matters that follow.

As a scientist, a follower of the baffling trail of truth, Karl Compton in the years before he was called to administer and guide for the well-being of others had made discoveries which advanced the noble discipline of physics. His published papers recording this achievement total more than a hundred, ranging from discussions of photoelectric phenomena to considerations of spectroscopy in the extreme ultraviolet. From this devotion of his to the advancement of learning in the field of physics grew his conviction of the necessity of consolidation and collaboration in the efforts of scholars in that field and, as a consequence, his achievement as principal creator of the American Institute of Physics. Beyond question, the course of development of physics was furthered and accelerated through Karl Compton's contributions. As one of his colleagues has said, "He was one of science's proudest examples of what a scientist should be and do."

But his work as a scientist was not confined to his accomplishments in research and in the focusing of creative effort. It was in no small measure as a teacher that Karl Compton gave effectively of himself to the advancement of learning. At Reed College and at Princeton University, his power to impart knowledge and, beyond that, to fire learning minds with the urge and the determination to press on with the search for comprehension, is today a proud tradition. At the Massachusetts Institute of Technology the devotion to the truth and its advancement, which in the earlier days had made him an inspiration to students directly, of necessity took its expression in the reshaping and evolving of the institution and its program as a whole. The advances in practice and in philosophy which took place at the Institute in the years following 1930 are the impressive record of the achievements of Karl Compton the statesman in education who had grown out of Karl Compton the teacher in lecture hall and laboratory.

Partly in parallel and partly in sequence with this evolving of the inspired researcher and teacher into the creative guide and administrator in university affairs was the growth of Karl Compton's share in the nation's trials and responsibilities. During the First World War he had engaged in the development of submarine detection devices and had later become an officer of the Research Information Service and an associate scientific attaché to the United States Embassy in Paris. Between wars, as Chairman of the National Science Advisory Board and in many other capacities, he was an eloquent advocate for putting science to work for the national welfare. When the threat of the Second World War loomed Dr. Compton served as a member of the War Resources Board in 1940. In June of that year he became a member of the National Defense Research Committee, later to be expanded as the Office of Scientific Research and Development. It was through this agency that Dr. Compton gave of his best to the nation during the entire struggle, so effectively that the citation accompanying his Medal of Merit declared that he personally had been responsible for shortening the duration of the war. Directly responsible, as head of the famous Division 14 of the O.S.R.D., for American radar development, Dr. Compton made his counsel and wisdom available in other fields as well, including the development of atomic weapons. Shortly before the end of the war he had gone to the Pacific to direct the Office of Field Service of the O.S.R.D., and when Japan surrendered, as one of the first civilians to reach the island, he led a survey of the status of Japanese military science. In these and many other ways he rendered a vast service to our country.

This judicial capacity of his was to be called upon again in the years after the war when in 1948 he was called to the chairmanship of the Research and Development Board of the National Military Establishment. The statesmanship which produced these wartime calls had its peacetime analogue in the many requests, to which he generously acceded, that he hold posts in government, foundations and public trusts as well as in industrial corporations. Among these should be recited the Ford Foundation, the Rockefeller Foundation, the Sloan Foundation and the Sloan-Kettering Institute.

Massachusetts Institute of Technology will go forward in accomplishment in the years ahead, expanding science and technology, stimulating the worthy ambitions of youth, serving its country in time of need. It will continue to be a body of scholars bound together in friendly relationship for creative effort. It will proceed on this path with greater assurance and devotion because of the life of Karl Taylor Compton and because his inspiration will long endure in all our hearts.

In expressing its deep sense of loss in the death of its Chairman, Karl Taylor Compton, the Corporation of the Massachusetts Institute of Technology inscribes this tribute to him and resolves that it be made a part of the permanent record and that copies be sent to his family.

Respectfully submitted,

VANNEVAR BUSH
JAMES R. KILLIAN, JR.
ALFRED L. LOOMIS
GERARD SWOPE

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The Trend of Affairs

Edna – in Three Dimensions

NEW ENGLAND is noteworthy for the variety of its weather and the rapidity with which it changes. The northeast segment of the United States is not usually regarded as being in the hurricane belt, but the tornado that struck central Massachusetts in June, 1953, and the hurricanes that visited New England in 1938 and 1944 – together with Carol and Edna, striking on August 31 and September 11, respectively, of this year – leave little doubt but that occasionally New England residents can expect disastrous winds of greater than gale velocity.

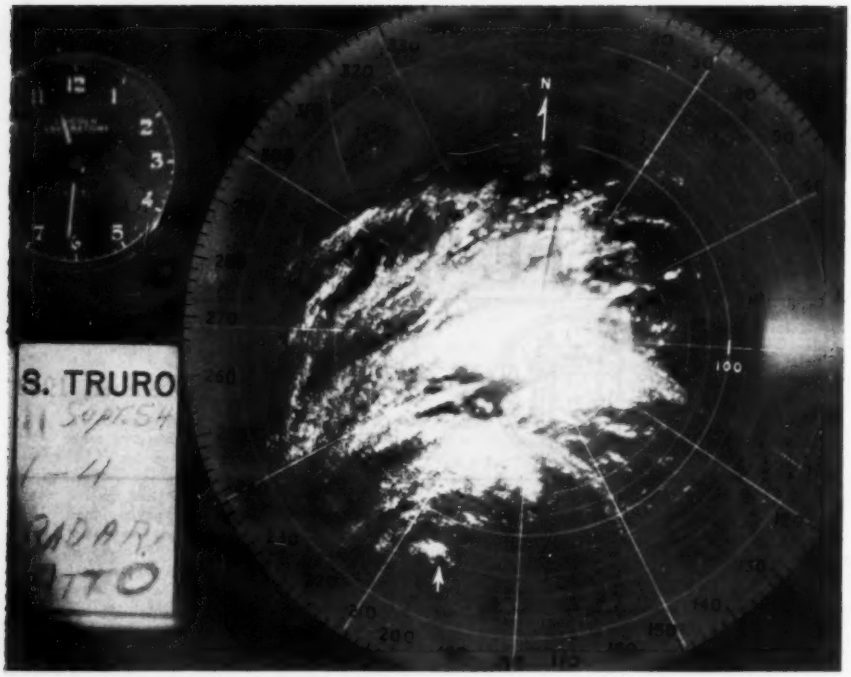
Although less damaging to life and property than its predecessor of August 31, the course of Hurricane Edna was photographed by radar from many angles, and its progress was carefully plotted. As it swirled up the Atlantic seaboard, radar photographs of Edna show what is believed to be the first three-dimensional radar information about a disastrous tropical storm at the height of its fury.

Some of these unusual photographs show the great storm while it was still about 125 miles southwest of M.I.T.'s radar station at South Truro, Cape Cod. The photographs were made by a group of M.I.T. radar engineers and meteorologists of the Air Force Research Center from Cambridge, who, for more than 30 hours of exciting and exhausting activity, plotted the weary wet miles of the hurricane's course to New England. No less than 8,000 photographs were made of Edna during the course of her tempestuous personal appearance tour from the Caribbean to the Bay of Fundy.

When it became apparent that the hurricane would strike the New England Coast, the M.I.T. Department of Meteorology, the Air Force Cambridge Research Center, the M.I.T. Lincoln Laboratory, and the Air Force Base at Hanscom Field (Bedford Airport), quickly improvised a network of emergency weather observation and reporting stations. In addition to extra cameras for radar photography, emergency power sources and auxiliary communication systems were set up in case normal power and telephone services were disrupted. Normal local weather forecasts were augmented and nearby airfields were advised continuously of the hurricane's force and direction in order that aircraft necessarily left in the open on airfields could be protected as much as possible.

By Friday evening, September 10, a group of engineers and meteorologists, all volunteers, began their vigil at the South Truro radar site. From that time on, radar observations, temperature, barometric pressure, wind force and direction, and other information on the storm came in by radio, not only from the Truro station, but from other M.I.T. radar stations at Chatham, Nantucket, and Clinton. These reports, received at Lincoln Laboratory in Lexington, were immediately relayed to Bedford Air Base, from which the information was teletyped to weather bureaus and forecasting stations throughout the East as far inland as Ohio. The Air Force radar station at North Truro and the M.I.T. Department of Meteorology also kept the U.S. Weather Bureau and Logan Airport fully informed on their observations of the storm.

One of the first radar photographs taken on Friday at 9:05 P.M., September 10, indicated a typical high overcast condition. Two hours and 15 minutes later the outer band of rain triggered by the hurricane, was detected approaching the Cape Cod area. This band of precipitation, a heavy curtain of rain 30,000 feet high, arrived and was photographed over South Truro at 1:02 A.M. on Saturday, September 11, while the eye of the onrushing storm was still approximately 450 miles to the southwest and about 75 miles due east of Cape Hatteras. Photographs showed that this first band of precipitation was made up of a number of thunderstorm cells and was accompanied by con-



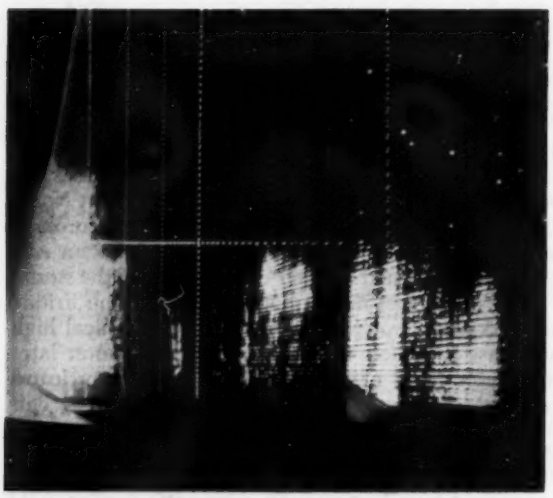
Radar "map" showing the heavy rainfall which occurred during Hurricane Edna, as photographed at the Project Lincoln radar site at South Truro on Cape Cod. At the time this photograph was made, the center of the storm, indicated by arrow head, was about 125 miles distant.

siderable lightning. This initial band was followed by successive violent rain squalls rotating around the eye of the storm in the usual counterclockwise direction. These squalls increased in frequency and in the intensity of the rainfall, and by dawn Hurricane Edna had doubled its forward speed and was lashing northeastward at 32 miles per hour.

By early Saturday morning observations showed that the hurricane was wider in area than was originally anticipated, with strong winds extending 125 miles on the seaward side and 50 miles toward the coast. At 10:55 A.M. on Saturday observations indicated that the eye of the storm was 150 miles and 200 degrees southwest from South Truro on a parallel with the Naval Air Station at Lakehurst and McGuire Air Force Base in New Jersey.

As the eye of the storm approached and passed over South Truro the radar cameras saw and photographed the hurricane in three dimensions; the range, azimuth, and height of the precipitation bands. At approximately five o'clock Hurricane Edna had passed the tip of Cape Cod and the observers, unrelieved for 32 hours of continuous observation and without food except for a pot of oatmeal hastily prepared on Saturday morning, were able to rest. During this period, at the various stations, approximately 8,000 photographs were made. This great collection of unique photographs includes invaluable information for further studies of a tropical hurricane.

The M.I.T. meteorologists are contemplating a symposium to correlate data from all sources throughout the eastern sector of the United States. The studies could result in development of techniques for determining wind velocities and predicting courses of hurricanes by use of radar, they believe.



The photograph above indicates the vertical cross section of Hurricane Edna and shows the bands of precipitation to the southwest, toward the eye of the hurricane. The technique which was used to obtain this photograph is believed to be a new one in radar meteorology.

A 32-hour vigil of radar operations, in which the Institute's Department of Meteorology took an active role, surveyed the second of the season's hurricanes to strike New England continuously, until it moved northeast over Cape Cod, and out into the Atlantic Ocean.

Fresh Water from the Sea

Serious Water Shortages Could Be Alleviated

but Conversion Costs, by Existing Methods, Are High

By THOMAS K. SHERWOOD

For thousands of years man's major concern was how to stay alive. With the rise of science and technology the problem of physical existence has been largely solved, so that in technologically advanced nations the problem today is not that of continuing to live, but how to live better. But technology's great contributions to the problem of physical existence have been made in an era of plentiful natural resources, and mankind is faced with the grave possibility that the development of science and technology may not keep pace with the continued depletion of the natural resources with which we have been blessed. In the year 2500 A.D., will the race again be faced by the age-old problem of existence? Fairfield Osborn's book[8]* *Our Plundered Planet* and the panel discussions of the M.I.T. Mid-Century Convocation[2] typify our natural concern regarding the future availability of the things we have come to believe essential for material welfare.

Our elementary needs are air, water, food, and shelter. Even today the problem of food is serious in many lands, for the population continues to grow while the use of arable land approaches a limit. Mineral resources are being depleted at an alarming rate and sources of energy from oil and fuel are clearly limited. The United States must now import many of its essential raw materials, including nickel, zinc, copper, and even petroleum and lumber. The potentially serious shortage of water, the most abundant of all substances, emphasizes the problem of the future.

It is an oversimplication to determine that the available supplies of oil, or iron ore, or some other resource, will last x years at the present rate of consumption. For each is available in deposits of widely varying quality, and the richer and more accessible are naturally extracted first, at low cost. As depletion of reserves proceeds, the less desirable are processed at increased cost in terms of effort and investment. The development of water power illustrates the pattern. The first power sites selected are those near population centers and requiring the least investment. Less desirable sites are developed later at greater expense per kilowatt. Accessible high-grade iron ore is already approaching depletion and the poorer deposits of taconite and the more remote deposits of Labrador and Venezuela are now being exploited. Mineral deposits will perhaps never be entirely depleted (there is iron in the ocean), but the costs of extraction continue to rise and become prohibitive for one use after another.

This is like the depletion of firewood near a much used campsite. The first campers break up the dead wood lying near at hand. In time the area becomes so depleted of good wood that it is necessary to carry large logs a considerable distance, as at the camp sites in some of our national parks.

This pattern has in it an element of the vicious circle. The poorer the quality of the reserve, the more plant is needed for the processing. Much greater investment is needed to obtain gasoline from coal or shale than from oil, or to obtain iron from low-grade ore. The result is that more of the product is used to produce the product, until, in the limit, all of the raw materials may be needed to build the processing plants.

Most people have heard or read of the probable oil shortage, but the idea that there could be a serious water shortage may come to some as a shock. The common complaint is about the excessive rainfall at inconvenient times, and it is obvious that we use but a fraction of the rain which falls in our vicinity. Why not scoop up some of the excess as it flows past us on its way to the ocean? But complaints about too much rain in April and brown lawns in August illustrate the point. The problem is one of distribution in time and space to have the needed water at the right place at the right time.

The average rainfall in the United States is about 30 inches, providing 28,000 gallons for each person each day. This would seem to be much more than enough. But 70 per cent of this evaporates, and one third of the rest disappears underground and cannot easily be caught. This leaves 5,600 gallons per day per person which we can have if we can catch it. The total water used averages a little more than 1,100 gallons per day for each person, so our efficiency in collecting and using the water provided by rainfall is nearly 20 per cent.

This seems surprisingly high when it is remembered that the rainfall varies so widely over the country and through the four seasons of the year. The utilization is poor in some parts of the Northwest where the rainfall is 120 inches, and very high, indeed, in the southwestern states, where the average fall is less than five inches. The runoff averages somewhat higher per person in the 17 western states than for the rest of the country, but the use is much higher in the East because of the proportionately higher concentration of industry. An average utilization of 20 per cent means not only very high utilization in certain areas during parts of the year but, inevitably, frequent actual water shortages.

* Please see numbered references at end of article, page 60.

The water problem is already with us. In the first eight months of last year 1,031 cities and towns reported enforced curtailment of water use—over half of these instances being due to inadequate supply.[9] The recent experience of New York City is typical, with car washing banned and restaurant patrons requested not to drink water. In almost every instance, increased demand contributed to the shortage. Between 1950 and 1975 the population is expected to increase 27 per cent, and the water demand to double.[10]

The situation in southern California is so serious that they not only bring water 300 miles from the Colorado River, but a plan is afoot to transport water the length of the state, from the Klamath River. Ground water is being withdrawn at the rate of 1.4 billion gallons per day in the high plains of West Texas – 30 times the rate of replenishment. Ground water pumping in southern California has caused intrusion of salt water from the sea. Water-deficient areas are increasing in number and size. Near Chicago the subsoil water table has been lowered by 500 feet. City after city is limiting the use of water for the cooling of air-conditioning equipment, or requiring its return to the subsoil. Larger and more expensive reservoirs are being constructed. Three quarters of the flow of the Missouri at Kansas City last October was released from the Fort Peck Reservoir in Montana. Without this the river stage would have been but two inches above the minimum required for city water and sanitation.[9] No appreciable increase in the country's water supply is in sight, but the need increases steadily.

There are many ways of alleviating the situation, but no simple solution to the problem. More large dams can be built to save water for dry periods. Perhaps cloud-seeding with dry ice or silver iodide can be developed to produce more rain where and when needed. Certain large supplies of brackish waters can be purified at reasonable cost. Seacoast cities, if necessary, can install a second set of water mains to carry sea water for sanitary and fire-fighting purposes. More effective re-use of water for industrial purposes, as by the greater use of cooling towers, can save large quantities of water. In this connection it is notable that one oil refinery in Texas re-uses water to the extent that its 600,000,000 gallon per day requirement involves only 40,000,000 gallons per day of new water.[10] Since half of the available water is used for irrigation, there exists the possibility of more municipal and industrial water by reapportionment – at the expense of a reduction in cultivated acreage.

Many of these conservation measures can be effective and important, but the trend of the demand curve makes it clear that in the long run (say 50-200 years) they cannot be sufficient. Why then, not get the needed water from the greatest of all water resources – the sea? Sea water is 96.5 per cent pure water, and directly available to those states in which more than two thirds of the people live, and in which a somewhat larger fraction of industry is located. One cubic mile of the ocean contains enough pure water to supply the needs of the entire nation for nearly eight days. Many methods of separating pure from salt water are known, and some have been used for centuries. Sea water contains more than 800 times as much water as magnesium, yet magnesium metal is now obtained commercially from sea water and sold at a profit. Why, then, should not all our water needs be satisfied by producing fresh water from the sea?

The answer to this question is basically simple. We can – at a price. But the significance of the price is not easy to assess. In order to do this it is necessary to compare the probable cost with the water prices we are accustomed to pay. Large users of water for irrigation pay about one-half cent per 1,000 gallons, though the price may range up to $0.12. Industrial water prices are in the vicinity of $0.04 to $0.05 per 1,000 gallons, and a typical price for delivered city water is $0.25 per 1,000 gallons. There may be communities in the Southwest which would be glad to have fresh water delivered at $0.50 per 1,000 gallons. Very little irrigation water would now be bought for more than $0.10 and very little city water at more than $0.40. At the present time, therefore, water from the sea would have to be produced at less than about $0.40 per 1,000 gallons, though this limit may be expected to increase as the demand for water grows over the years.

In attempting to assess the possibilities of cheap water from the sea, we have one exceedingly valuable guide. This is the second law of thermodynamics, from which we can deduce that the minimum amount of power required to separate 1,000 gallons of fresh water from sea water is 2.8 kilowatt-hours. This would operate a 100-watt light bulb for 28 hours. The second law is one of the most reliable laws of nature ever discovered, and it is quite certain that the figure of 2.8 kilowatt-hours per 1,000 gallons will never be bettered by any process yet to be invented.

It is important to understand the significance of this figure. It is the required work energy when operating an ideal process infinitely slowly, with no losses or inefficiencies of any kind. Every real process will require more than the minimum figure; we would be fortunate indeed if we could accomplish the water separation with the expenditure of twice the minimum, or 5.6 kilowatt-hours per 1,000 gallons. Even this is somewhat wishful thinking, since we have no process which even approaches this larger figure. At the low power rate of 0.5 cent per kilowatt-hours, the power cost alone will then be at least $0.028.

Thermodynamics suggests nothing about plant costs, except that they may be expected to be infinite if the minimum energy requirement is to be attained. In plant processes of the types to be discussed, the fixed charges usually run about twice the energy costs. On this basis, it appears that about the best that can be hoped for is a total cost of $0.084 per 1,000 gallons of fresh water. No existing process can approach this figure, but what cost might reasonably be attained?

In order to make an educated guess as to the possibilities of coming close to the target of $0.08 to $0.09 per 1,000 gallons, it is necessary to consider some of the methods which may be employed to process sea water for the purpose. Science suggests many methods, but none are very good. If methods now known

are to be used the problem is one for engineers rather than for scientists, since energy costs must be balanced against plant costs to obtain the optimum result. Engineering skill and judgment are required, and there is no clean-cut or simple answer to the question of what the minimum practical cost may be. It is possible, however, to estimate with some assurance the general cost ranges for the various processes.

Vaporization

The most familiar method of separating water from a salt solution is to boil it and condense the vapor on a cold surface (see Fig. 1). The salt does not vaporize, and the condensed steam is pure water. But the heat input amounts to 2,800 kilowatt-hours per 1,000 gallons – just one thousand times the theoretical minimum. This is certainly not very good.

But the chemical engineers have a trick. Let the steam formed condense to heat a second vessel of boiling sea water, and the steam formed in the second go to heat a third, and so on (see Fig. 2). Then in three vessels nearly three pounds of pure water would be obtained from sea water, at the expense of just one pound of steam fed. This is called "multiple-effect distillation." Vacuum equipment is required to operate so that each successive vessel is at a lower temperature, but it is not impractical to cut the required heat input for boiling by 75 per cent if four or five vessels are used in series.

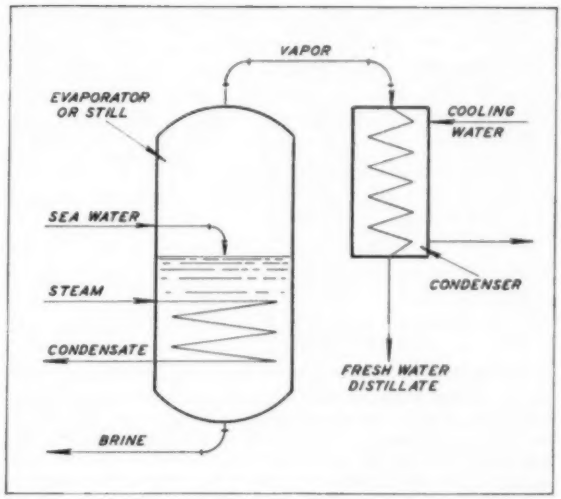


Fig. 1 Diagram for simple distillation apparatus. A portion of the sea water is vaporized in a steam-heated kettle and salt-free vapor is condensed to produce pure water distillate.

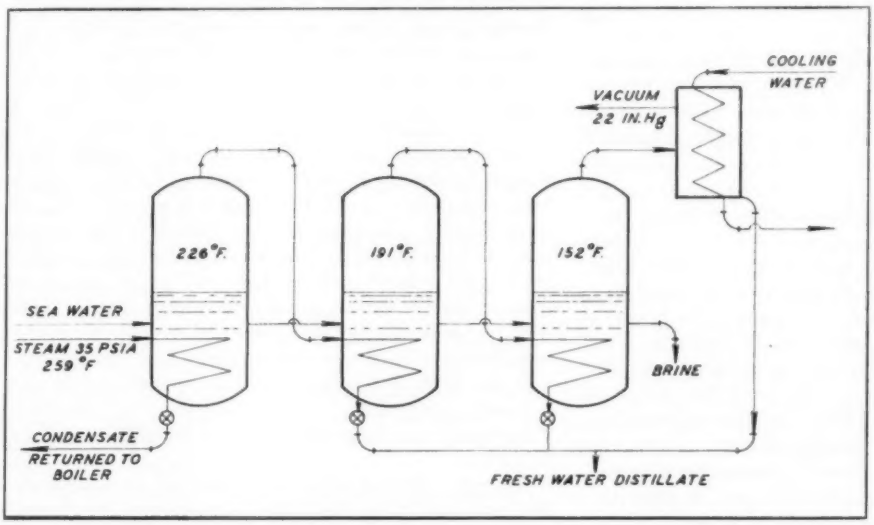


Fig. 2. Diagram for multiple-effect distillation apparatus. The first kettle is heated by steam; the second is heated by vapor from the first. A vacuum is held in the last kettle. Boiling occurs at a lower temperature in succeeding kettles, providing necessary temperature difference for heat transfer.

The multiple-effect trick, then, can cut the heat requirement to perhaps 700 kilowatt-hours per 1,000 gallons – still a long way from the theoretical minimum of 2.8. But this input is heat energy, which is only about one quarter as valuable as work energy, in terms of which the 2.8 kilowatt-hours is expressed. On a comparable basis, then, the 2.8 figure is to be compared with one quarter of 700, or 175 kilowatt-hours. Even so, the costs of doing the job in this way are prohibitive. Using present-day costs for heating steam, cooling water, and equipment, and taking annual fixed charges as 15 per cent of plant costs, total cost of obtaining fresh water by this method is something like $3.80 per thousand gallons.[12]

This is about 10 times too high to be of much interest, though the process is used in unusual situations. The Navy uses it on ship-board, and there are installations of this type on the islands of Bermuda, Aruba, and Curaçao, which also import fresh water by tanker. At Kuwait, in the Persian Gulf, a multiple-effect distillation unit is now being installed to meet the need of a large oil refinery for nearly 1,000,000 gallons of water per day. Our own water shortages do not yet justify the cost of water by this process.

A unique variation of the simple distillation method[7] was used during World War II, primarily to fill the need for fresh water on submarines and for advanced shore bases in arid lands (see Fig. 3). A single, simple boiler is used, heated by its own vapor. This is made possible by slightly compressing the vapor coming off the boiling sea water, so that it will condense at a somewhat higher temperature. The compressed vapor is fed into a submerged heating coil, from which condensed fresh water is withdrawn. By employing suitable equipment to exchange heat between the feed and effluent streams, this type of still can operate without any heat input whatever. This seems like something for nothing, until it is

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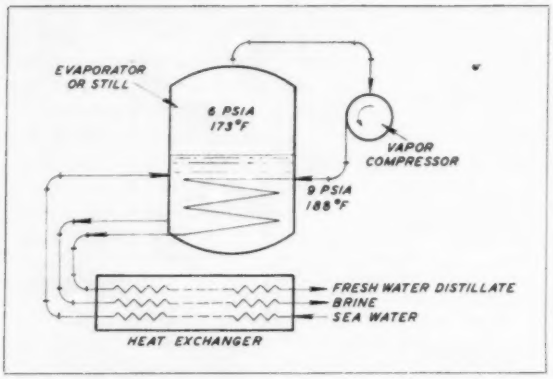


Fig. 3. Sketch of apparatus for vapor compression distillation. Sea-water is boiled in a kettle at reduced pressure. The vapor formed is mechanically compressed to a slightly higher pressure and temperature, and is then condensed to provide heat needed for boiling. Power is required to operate the compressor, but no net heat input is needed.

remembered that the vapor has to be compressed, requiring a power supply.

During the war stills of this type were built in such number as to fulfill the daily water needs of nearly 1,000,000 men, and the practicality of the device is well proven. The power requirement of present vapor compression stills is roughly 70 kilowatt-hours per 1,000 gallons of fresh water, and the input is the valuable work-energy, not heat. This is better than multiple effect distillation, though still far from the theoretical minimum of 2.8. The equipment is relatively expensive, and the total cost of water by this process, with power at 0.5 cent per kilowatt-hours and fixed charges at 15 per cent, is of the order of $1.70 per 1,000 gallons.[12] Here in the continental United States we are not yet that thirsty! It may be noted, however, that this process appears to be subject to considerable improvement, and it may be possible to bring the cost down to somewhere in the vicinity of $1.00 per 1,000 gallons.

When distillation is employed it is the usual practice to vaporize only part of the water and to discard a concentrated brine. Could not the evaporation be carried further so as to recover the magnesium and other valuable chemicals known to be present in the sea water? Again the answer is yes – at a price.

The present market value of the chemicals is more than $3.00 per 1,000 gallons – more than the cost of obtaining water by vapor compression distillation. (Gold would be one of the by-products, but its value would be only one one-hundredth of a cent per 1,000 gallons.) But the process costs for the water would go up sharply if the mixed salts were to be separated, and the costs of purifying and selling the chemicals would be enormous. Common salt, bromine, magnesium chloride, magnesium hydroxide, and gypsum are now obtained commercially from sea water, but without the simultaneous separation of pure water. If both water and salts were to be separated, the job would be considerably more difficult. The average per capita water requirement corresponds to more than 50 tons of by-product salts per year, and no possible use for such quantities of these chemicals is apparent, even if they were free. It seems unlikely that the recovery and sale of by-product chemicals will help the fresh-water cost picture except in special situations.

Solar Distillation

Since distillation is expensive in terms of energy required, solar energy would appear to be just the thing. The less rain the more sun and, therefore, the more water. Low-temperature heat is adequate for the purpose, and solar energy lands on large areas of the United States with sufficient intensity to evaporate an average of a little more than one pound of water every day for each square foot.

This process has been tested on something more than a pilot-plant scale, for it is nature's process of evaporation from the oceans to produce fresh rain water. Man has produced crude salt by solar evaporation of sea water since time immemorial. Even today salt is produced in this way in many parts of the world, and a company operating at the Dead Sea is so scientific that they add a small amount of green dye to the water to increase the utilization of solar energy in the shallow beds in which the water is exposed. Eighty years ago a mining company in Chile installed a solar distillation unit which produced 5,000 gallons of fresh water per day for their mules. An area of 51,000 square feet was covered with sloping glass panels over shallow water reservoirs. The sunlight passing through the glass vaporized water from the pools underneath and the vapor formed condensed on the under surface of the glass. The condensate drained down the sloping glass and was collected in a system of gutters. The glass breakage was high, but water was at a great premium and the unit operated for many years until a railroad was completed and fresh water could be transported to the mine.

Modern solar distillation units are of essentially the same design as the Chilean installation, but better

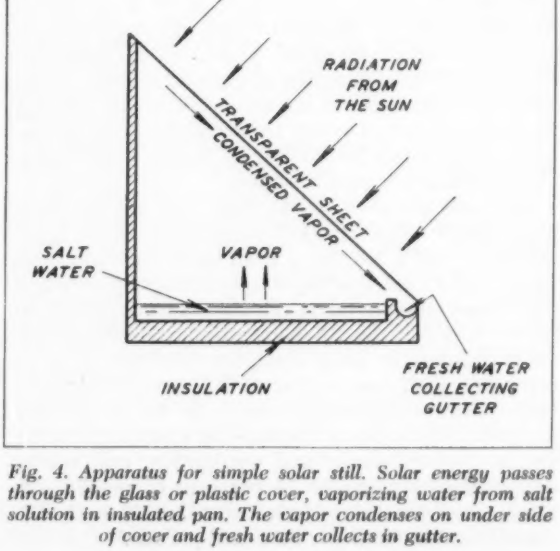


Fig. 4. Apparatus for simple solar still. Solar energy passes through the glass or plastic cover, vaporizing water from salt solution in insulated pan. The vapor condenses on under side of cover and fresh water collects in gutter.

glass and insulation are used and the efficiency of solar energy utilization is higher (see Fig. 4). A unique variation of the sloping glass-plate design was developed by Maria Telkes at M.I.T. during World War II. This was a small inflatable plastic balloon used on life rafts to produce drinking water at sea. Weighing about one pound, this device could be folded into a package of 60 cubic inches, but in use was inflated and floated on a towline attached to the raft. This ingenious still utilized about 60 per cent of the incident solar energy for the production of potable water.

Solar distillation is perhaps the simplest of all methods of producing fresh water from the sea, but like so many of the other workable methods, it is not cheap. No fuel is used, and the only power is for the distribution and collection of the water streams. But the first cost of the solar-energy collectors is high in proportion to the rate of water production. Glass-plate collectors are estimated to cost at least $1.00 per square foot, although new designs intended for mass production might cut this considerably. Then there is the sea water piping and the fresh water collection system. As a very approximate estimate, suppose the entire costs were to be taken as equal to the fixed charges at 15 per cent per year on collectors which cost $1.00 per square foot. Then if the average production were 1.2 pounds fresh water per day from each square foot, the fresh water cost would be $2.85 per 1,000 gallons. This is prohibitive at the present time.

Either the collectors cost too much or the intensity of the solar radiation is too weak. To produce all of the water the country uses for all purposes other than irrigation, the needed collectors would cover an area equal to that of Massachusetts, Connecticut, and New Mexico. Put another way, the water produced by solar stills is sufficient to irrigate land of about the same area as covered by the stills.

These figures tend to put solar energy collectors in a much worse light than is warranted. The collectors themselves are remarkably cheap and their efficiency in the collection of solar energy (50-70 per cent) is high. The basic difficulty is the very low efficiency in the subsequent utilization of the energy to separate water and salt. The thermodynamic efficiency is well under 1 per cent for simple distillation. If this could be raised to 10 per cent, solar stills would be widely used.

Freezing

Another trick of nature to produce fresh water from sea water is to freeze it. Freshly formed sea ice has a great deal of concentrated salt water trapped in the cracks between the tiny ice crystals, and the melted ice is not potable. It is true that old polar ice is nearly free of salt, but we can't very well afford to store large quantities of ice a year or more while it purifies itself. German and Italian experiments have shown that ice frozen slowly from agitated sea water can be centrifuged and washed to yield ice which when melted will give satisfactory drinking water. Perhaps the discovery of some simple chemical additive may obviate the salt-inclusion problem.

The heat energy which must be removed in order to freeze water amounts to only about one seventh of the heat input needed to boil water. But a refrigerator must be used to "pump up" this heat to the temperature of available cooling water, which might be the sea itself. Still better, since the ice formed must later be melted, the heat could be delivered to the ice at 32 degrees F., and the power to operate the refrigerator would then be very much reduced. The melting ice can accept only part of the heat to be dissipated, so a second refrigerator would be needed to deliver the rest of the heat to the sea. Ellis[3] estimates the theoretical power requirement of this ingenious cycle as 26 kilowatt-hours per 1,000 gallons, and it may be guessed that the actual power would be in the vicinity of 50 kilowatt-hours per 1,000 gallons. The equipment is of a moderately expensive type, so the fixed charges could be expected to be at least twice the power cost. With power at 0.5 cent per kilowatt-hours the total cost would then be $0.75, per 1,000 gallons. This is probably low (Aultman's estimate[1] is $1.25 or more) since there are many unknown problems in freezing and washing the ice to minimize occluded salt, but it would appear that the process might possibly be developed to become competitive with vapor-compression distillation.

Chemical Methods

All of the methods of sea water purification discussed so far require the separation of the water from the salt solution, and the trouble and expense is proportional to the amount of water removed. But the salt amounts to only one twenty-eighth the weight of the water, so it would appear more reasonable to separate out the salt rather than the water. There are many ways of doing this, most of them involving the use of chemicals.

Straight precipitation without re-use of the chemicals is easily seen to be extremely expensive. Suppose, for example, that the chemicals added cost only $0.10 per pound, and that the amounts needed were equivalent to the weight of the salts. Then $30 worth of chemicals would be needed to remove the 300 pounds of salt present in 1,000 gallons of sea water.

The new ion-exchange resins will remove salts from sea water and can be regenerated for re-use. One type of resin will remove the cations – the sodium, magnesium, and other metals – replacing these with hydrogen ion to form an acid effluent. This solution is then passed over a second resin to remove the anions – the chloride and sulfate ions of the original salts. The water is not only purified but new fresh water is manufactured in the process. But if the expensive resins are then to be used again they must be regenerated with purchased chemicals – acids and bases – and the result is about the same as in the case of direct precipitation. The chemicals used are relatively cheap, but must be used in large quantities. Furthermore, some of the pure water made is used to wash the resin bed, so the total cost of the fresh water is something like $20 per 1,000 gallons – $17 for the chemicals, plus the process costs. Direct power is used only for pumping, but

the power required to manufacture the needed chemicals is estimated at 200 kilowatt-hours per 1,000 gallons of fresh water.[6]

The use of an organic liquid solvent to extract the salt seems to offer still less promise. The salts must have a greater affinity for the solvent than for water if this scheme is to work. If this is the case, then it would seem to be even more difficult to separate the salts from the solvent than from sea water. The solvent would have to be recovered and used again if the process were to be economical.

Electrolytic Methods

Salts exist in a water solution in the form of electrically charged fragments, or ions, which can be persuaded to move out of the solution by application of an electrical potential. The ion fragments of common salt, for example, are deposited as sodium at one electrode and chlorine at the other. The sodium reacts with water to produce sodium hydroxide and hydrogen, and the chloride ion reacts with water at the other electrode to produce hydrochloric acid and either oxygen or chlorine gas. By employing suitable porous diaphragms it is possible to separate the purified water from the caustic and acid produced simultaneously. The lecture-table experiment demonstrating electrolysis is familiar to every college freshman.

Each ion separated in this way requires a definite amount of electricity, which for sea water amounts to some 500,000,000 coulombs per 1,000 gallons fresh water. The voltage required is about 1.2 volts, so the power is of the order of 170 kilowatt-hours per 1,000 gallons. Even though the by-product hydrogen and oxygen would have value, at least as fuel, the direct electrolysis process is evidently not competitive with other separation methods.

In theory, it should be possible to recover much of the power expended by allowing the hydrogen to recombine with the oxygen or chlorine in such a way as to produce electrical energy. Such a "fuel cell" has long been a dream of scientists, but has never been made practical. Alternatively, one of the electrodes employed might be silver and the other silver chloride: the sodium deposited on the silver chloride would reform common salt, and the chlorine deposited on the silver would form silver chloride. As electrolysis proceeded the silver and silver chloride would change places. The result would be the same as selling the hydrogen and oxygen, but the saving would show up in the form of a voltage reduction from 1.2 to about 0.5 volts. This scheme, which has never been developed to the point of practical application, would involve something like 70 kilowatt-hours per 1,000 gallons,[3] and the total cost, even with power at 0.5 cent per kilowatt-hour, could be expected to be $1.50 or more per 1,000 gallons of good water.

Like the chemical methods of separation, electrolysis has the merit of working on the salt content instead of the larger water content of the sea water. The cost is high because the separation is too complete: the salt ions are not only moved out of the solutions but their charges are neutralized with expensive electricity. The recent development of ion exchange resin sheets permeable to only one of the two kinds of ions provides a way of avoiding the costly neutralization of the ions by using electric power only for the separation process itself.

The basis of this new process is the development of porous plastic sheets consisting of resin molecules charged either positively or negatively. These sheets contain a great deal of water, and the negatively charged sheets permit the passage of the sodium, magnesium, and other positive ion fragments of the sea-water salts, while preventing the passage of most of the negative ions. Similar positively charged sheets permit the passage of the negative ions — chloride and sulfate — and prevent the passage of metal ions. A relatively small applied voltage persuades the salt ions to pass through these sheets, along with a very little water.

One scheme is to arrange alternate membrane sheets of the two kinds of material so as to enclose

(*Continued on page 54*)

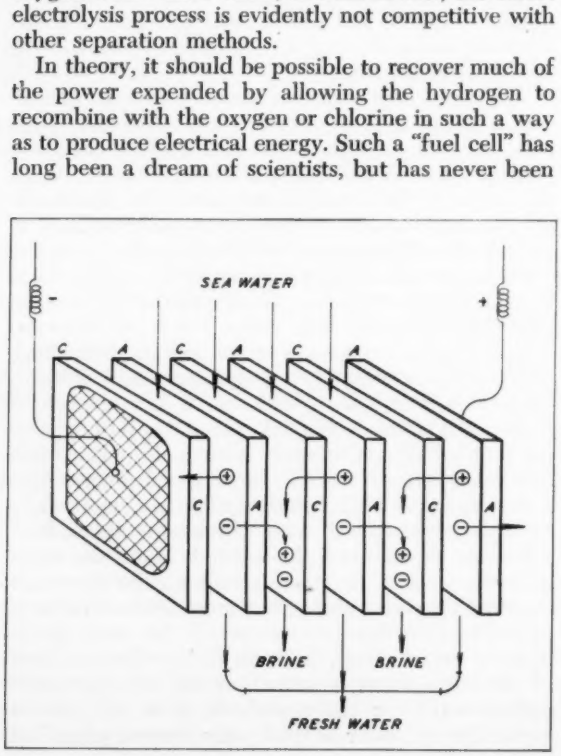


Fig. 5. (Left) *Ion-selective membranes, C, permit passage of sodium and other positive ions, while membranes, A, pass only negative ions. Brine and fresh water are collected from alternate channels.*

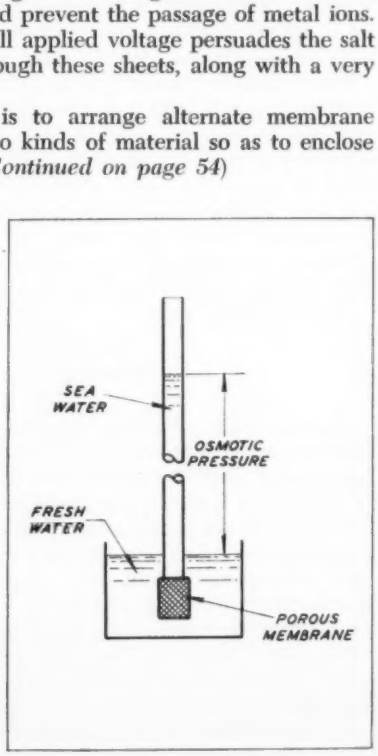


Fig. 6. (Right) *Fresh water can be formed from sea water by forcing latter through a porous membrane permeable to water but not salt.*

The Process of Aging

As We Become a Nation of Older People

There Is Increasing Need to Learn

How to Grow Old Gracefully

By JAMES A. TOBEY

One of the seemingly inevitable features of life is that strange interlude known as senescence, the process of aging which culminates, sooner or later, in death. Why do we grow old, when and how do we grow old? What, if anything, can be done to retard, reverse, or alleviate this languishing condition of life? Is it really inevitable?

Unfortunately, no one can achieve immortality by giving precise, complete, or even very satisfactory answers to all of these vital questions. Much progress has been made in recent years in the new science of gerontology, and much has been written on the subject,* but actually we know very little about the details of the process of human aging. We do know, however, that it is not a pathological process but a physiological one, like childhood, which senescence resembles superficially. We know, too, that certain endogenous and exogenous conditions may accelerate or retard the process of aging. To date, no one has discovered how to prevent it.

The process of aging in man has been said, somewhat rashly, to begin at the time of his conception. This may be true of calendar age, but it is certainly not true of physiological age. It has also been asserted that human aging commences at birth, because even then certain cells of the body, in the ovaries and kidneys for example, go through a process of involution, or degeneration. This would seem, however, to be a rather farfetched definition of aging. Finally, it has been stated that, "the period of youth is the period of most rapid decline." This would seem to be unjustified pessimism.

Considering the human organism as the entity which it is, and accepting the definition of aging as the process of progressive unfavorable changes in the human machine, aging in the practical sense in the normal individual does not begin or become manifest until about the fourth decade of life. The first 20 years or so of human existence are devoted to growth and development, after which there ensues another 20 years of maturity and the prime of life. All during these periods involution and aging of various cells may and does occur, but after the age of 40 the process is accelerated in the average person and begins to affect organs and systems as well as cells. There is, of course, a tremendous variation in individual capacity for aging, due to heredity, the environment, and other factors.

From the age of about 50, however, the normal person invariably suffers a gradual diminution in mental and physical capacity. He may be reluctant to admit it, but he is slowing up. Among the obvious changes are the loss, or graying, of the hair; a less acute vision, particularly for dark adaption; possible impairment of hearing; loss of some or all of the teeth; reduction in the ability to perform fatiguing, muscular work; sometimes a lessened efficiency of the digestive system; an increase in blood pressure; a general decline in the basal metabolism; kidney troubles, and in men, prostate troubles; and less ability to cope with certain types of disease. By this time women have had the climacteric and have ceased to become fertile, and in men there is often diminished sexual potency.

As time marches on, as it does so inexorably, memories become less acute; the fine edge of judgment is dulled; the skin becomes sallow, wrinkled, and sagging; the bones are brittle and break easily; the gait becomes less vigorous and more shuffling; the posture is stooped and the body more or less shriveled; there is often an increase in the hardening of the arteries; the kidneys are much less efficient; bronchial troubles are more widespread; there is greater susceptibility to heat and cold; and the body is more prone to certain maladies. Finally, the individual exemplifies Shakespeare's description of Falstaff in the *Merry Wives of Windsor*, "old, cold, withered, and of intolerable entrails."

This is the common picture of the later decades of human life, but it does not apply to everyone. Occasionally we see children of 10 or 12 years of age who are prematurely old, suffering from the condition known as progeria, due to disturbances in the endocrine glands. Some persons are obviously old at 40 or 50, while others retain the characteristics of youth at 60 or even 70. Chronological age and physiological age are, in fact, two quite different matters, a proposition which has been consistently overlooked by those who set arbitrary and abrupt retirement at certain fixed ages, such as 60 or 65.

One of the most notable examples of an individual who was able to add life to his years and grow old gracefully was the late Charles W. Eliot, sometime professor of chemistry at M.I.T., who served as president of Harvard University for 40 years and as president-emeritus for another 17. More than a quarter of

* See, for example, the book of 1061 pages: *Problems of Ageing: Biological and Medical Aspects.* Edited by Albert I. Lansing, 3d edition (Baltimore: Williams and Wilkins Company, 1952).

a century ago, in 1925, I went to see him at his home in Cambridge, Mass. Arriving a little early, I awaited him in a small reception room at the head of the stairs. In a few minutes Dr. Eliot came in, bounded up the stairs like a youngster, greeted me by name, and sat down and discussed our business in a rational and highly instructive manner, and later wrote me a helpful letter about it. He was then 91 years of age, but assuredly his physiological age was many years less. He died about a year later at his summer home.

Another outstanding example of physiological youth in old age was that other eminent Yankee from Boston, Justice Oliver Wendell Holmes, who was active and useful on the bench of the Supreme Court of the United States beyond his 90th year. It will be recalled that Justice Holmes's father, the poet and physician, who died in 1894 at the age of 85, once wrote a colorful poem about "the wonderful one-hoss shay," a remarkable contraption which never wore out during long years of service, but finally disintegrated all at once. If the human body could be protected against infections, accidents, poisons, malnutrition, and other hazards throughout its normal span of life, it too might ultimately collapse merely from old age, somewhere in the vicinity of 100 years. Most scientists believe, however, that natural death due to old age never occurs. Every human death must be attributed to an accidental cause, such as heart disease, pneumonia, or some other exigency.

As a matter of fact, the human body does not wear out in a uniform manner, so that all organs degenerate at the same rate. Some cells, organs, and systems age faster and more completely than others, although again there is variation in individuals. At one time it was thought that aging of the cells was caused by their poisoning or intoxication, but this theory is not now accepted. Actually, some of the billions of different kinds of cells in the human body never age at all, while others age and die while the body lives, and still others merely age. Some cells may even survive the death of the individual by as much as 120 hours after that event, but in the end, "shall the dust return to the earth as it was."†

It is, of course, extremely difficult to study the aging process in living body cells, except the red blood cells, but use of radioactive tracer substances, human autopsy examinations, and experiments with laboratory animals have revealed certain changes during senescence. Among these senile changes are: a gradual retardation in the rate of cell division and a slowing up in the capacity of cell growth and tissue repair; a gradual diminution in the rate of tissue oxidation; cellular atrophy and degeneration, and increase in pigmentation and fatty infiltration of the cells; gradual decrease in elasticity of tissue and degenerative changes in connective tissue; decreased speed, strength, and endurance of skeletal neuromuscular reactions; and decreased strength of skeletal muscle.

Authorities seem agreed that the process of aging can be hastened or deferred by episodes and experiences in the earlier years of life. Repeated insults to the human machine, such as infections, severe allergies, injuries, strains, accidents, poisons, alcoholism, drug addiction, chronic malnutrition, obesity, shock, and continuous emotional turbulence, certainly cause changes in the body cells which are conducive to senescence. An occasional infection or injury does not cause permanent harm, because the body has remarkable powers of regeneration, but frequent bouts of disease, chronic afflictions, organic maladies, and persistent mental stress all produce an unnatural wear and tear on the body which tends to accelerate the aging process. Rehabilitation during youth is, therefore, of great significance to healthful longevity.

Postponement of the aging process seems to depend in the first instance upon heredity, since some genes, derived from a long line of ancestors, seem to favor longevity and a longer prime of life. Heredity, however, is modified by the environment, both the external and the internal. Recent provocative experiments indicate that aging can be deferred by slowing down the process of growth during youth, while other investigations have demonstrated that optimum nutrition throughout life will definitely prolong life and extend the prime of life. The only trouble with these interesting tests is the fact that they have been conducted on white rats, and not upon man himself. Now, a rat is not a man and is not likely to become one, although the reverse is sometimes true, and there may be some doubt as to whether these results can be translated precisely into human terms, despite the fact that rats have much the same nutritional requirements as humans. There is no doubt, however, that good nutrition is one of a number of very important factors in human health and longevity.

About three centuries ago a celebrated English physician, Dr. Thomas Sydenham, was responsible for the adage that, "A man is as old as his arteries." It is certainly true that diseases of the arteries then caused, and now cause, much disability and are the leading cause of death in this country today, but Dr. Sydenham's maxim no longer is accepted as valid. Arteriosclerosis, or hardening of the arteries, is a lesion which can be found to some degree in nearly all persons over 20 years of age, although in most instances it is not a serious condition. In the later decades of life this malady may become more severe, resulting in hypertension and stress on the heart.

In arteriosclerosis and its precursor, atherosclerosis, there is a deposition of lipid, or fatlike, material in the lining of the inner wall of the aorta and other major arteries, which constricts the volume and thus increases the rate of flow of the blood. In the later stages of this ailment there is degeneration and necrosis (death) of the tissue of the artery, with deposition of calcium in combination with other substances. The fatty plaque which initiates or accompanies arteriosclerosis is due to large molecules of a substance known as cholesterol, which is synthesized in the body and is carried in the blood stream. Whether the high serum cholesterol which is always found in arteriosclerosis, and also in certain other diseases such as diabetes and nephrosis, is a cause or an effect has not yet been accurately determined. Some foods, such as eggs, are high in cholesterol, but the evidence does not yet justify their interdiction in the diet.

Afflictions of the heart and arteries often can be avoided, according to Dr. Paul D. White of Boston,

(Concluded on page 62)

† Ecclesiastes 12:7

Aeronautical Technology in the U.S.S.R.

There Is Sufficient Reason to Assume That Any Aeronautical Gap Which Once Existed between the U.S.S.R. and the Western Powers Is All but Closed

By J. W. RIZIKA

CZARIST Russia had some brilliant pioneers in aerodynamics and aircraft design. Nevertheless, her aviation industry was little developed, and most of the flying machines were either imported or manufactured at home under foreign license. In 1914, it had been commonly believed that Russia was second only to France in military air power. However, the first few months of World War I demonstrated that there were relatively few aircraft fit for active service and that the Russian air power lagged pitifully behind that of the Germans.

The lack of production of Russian-designed airplanes, the insufficiency of manufacturing facilities, and the strain on the few existing Russian roads and rails in feeding and supplying the nation's armies made the supply of both additional aircraft and replacement parts increasingly difficult, and caused a deterioration of the Russian air power as the years progressed. Industrial production (of aircraft) had almost ceased to exist by 1919. By the end of the Bolshevik Revolution, Soviet Russia not only lacked production facilities but was also devoid of the majority of its technicians, mechanics, engineers, and scientists.

Lenin, influenced by A. N. Tupolev and N. E. Zhukovski,[1]* was soon convinced of the importance of the aviation industry to the Soviet Union. In 1918, even before the internal hostilities had subsided, Tupolev and Zhukovski founded the ZAGI (Central Aerodynamics and Hydrodynamics Research Institute). At the time of its inception, the ZAGI was responsible for all Soviet aeronautical research, development, and design, construction of aircraft, and the training of future aeronautical personnel. Professor Zhukovski spent most of his time with the problems of establishing a school, the Zhukovski Air Academy, and educating technicians, mechanics, and engineers. At the same time, Tupolev was forced to divide his time between the Zhukovski Air Academy and the building of aircraft. These two men, primarily the latter, came to be recognized as the fathers of aeronautics in the Soviet Union.

In 1922, Tupolev built a small-engined monoplane primarily constructed of wood, the ANT-1; at the same time, tests were carried out on a large twin-engined triplane, designed in 1920 and known as the *Komta*. It is believed that these airplanes represented the beginning of aircraft design under the Soviets.

During the early period of Soviet aeronautical development, it was imperative that the Soviet Union import equipment, technical knowledge, and personnel from abroad. It was at this time (1922) that Hugo Junkers, as well as many other German advisers and technical personnel, came to the Soviet Union to build the first modern aircraft plant, the Fili plant near Moscow. These German advisers had a marked effect on the early Soviet aero designs[2] – even today, the Junker influence can be noted in many of Tupolev's high-speed bomber craft.

By 1926, the responsibilities of the ZAGI had been decreased in extent and expanded in intensiveness. Though it no longer was responsible for the construction of aircraft, the ZAGI had become the central department for all the Soviet aeronautical research and development and, by 1926, it had become one of the largest technical aircraft establishments in the world. At this time, its equipment included three wind tunnels, one compressed air tunnel, a water tank 560 meters (about 1,800 feet or one third of a mile) long, three propeller test stands, two engine test cells, and various other accessory equipment.

By the end of the first Five-Year Plan (1932), the ZAGI shared its technical responsibilities with two other organizations: The ZAIM (Motor Research Institute), founded in 1930, was in charge of all aero-engine development work; and the VIAM (Materials Research Institute), founded in 1932, conducted and directed all the research and development work concerning materials and their properties.

It should be pointed out that the initial Soviet developments were concerned with strategic, as well as

This is the much discussed MiG-15 for which the U. S. Government paid $100,000 in the fall of 1953. The instruments are said to be copies of U. S., British, and German equipment, and the gun sight is reportedly a direct copy of one designed by the Sperry Gyroscope Company.

Don Nelson, Dayton Daily News

* Please see numbered addenda at end of article, page 26.

tactical, aircraft. The Soviets well recognized the importance of a strategic air arm. The industrial and productive limitations, however, forced the Soviet policy makers into making a choice between the two types of air forces. As a result, emphasis was placed on the tactical air units – that is, units that could be utilized as an aid to the ground forces. Similarly, in order to build an appreciable defensive air force quickly, quality had to be sacrificed for quantity. Thus, foreign prototypes played an important role in the early development and production. Almost all of the aero-engines used in the Soviet flying machines were of foreign designs; some of these were imported and many were produced under foreign license by the Soviet factories. The two outstanding Soviet aircraft designers of this period were Tupolev and K. A. Kalinin, the latter specializing in the design of commercial airplanes. Other notable early Soviet designers included O. K. Antonov, D. P. Grigorovitch, E. E. Groppius, W. O. Pisarenko, A. Poutiloff, and V. Shavrov. Yakolev was just beginning his career with the design of a two-place, sport monoplane.

Effect of the Purge Trials

The purge trials of the late 1930's had a drastically impressive effect on many of the leading Soviet aeronautical personnel. Aside from the extermination of many top military advisers, this purge left the Soviet Union with almost no leading aircraft designers. Kalinin, as well as many of his students, was executed. Because he stood up to defend the character of his students who were on trial, Tupolev was exiled from 1939 until 1942, when he later reappeared to design the Tu-2, a twin-engined attack-bomber. The absence of the established leaders of Soviet aircraft design was soon replaced by co-operative groups of younger and lesser-known men. Committees were formed to design many of the airplanes during this period; one of the outstanding committees was composed of Lavochkin,[3] Gorbunov, and Gudkov, which operated together from 1938 to 1943 and was responsible for the design of the LaGG[4] series of aircraft. Similarly, Mikoyan[5] and Gurevich[6] combined, and, in 1940, their first product, the MiG-1 (called the Russian Spitfire) appeared. Several modifications of this airplane were later built and, by the end of World War II, this team had designed a relatively large portion of the Soviet fighter airplanes.

The period following the purge trials also provided the opportunity for many of the younger designers to demonstrate their individual abilities. Ilyushin[7] gained prominence in the rapid design of the Il-2. This machine, a two-seated assault bomber, was a model in simplicity and, at the same time, was extremely heavily armored; it represented the Soviet response to the German panzer divisions during the early part of the war. Yakolev's[8] earlier successes with sport airplanes brought him quick recognition after the purge trials and, from 1940 to 1943, he designed eight airplanes – fighters, attack-bombers, transports, and trainers. During the war, German bombardments caused the destruction of Lavochkin's plant and the LaGG team soon broke up. Lavochkin then took the nucleus of his staff beyond the Urals; it was not long before he had designed, and his plant was producing from native materials, the La-5, a low-winged, single-seated fighter.

Exterior Aid during the War Years

During the war years, from 1941 to 1945, the Soviets received numerous forms of aid from the other allied nations. Technical and tactical aid from American and British advisory committees helped the Soviets to modernize their air forces. It took the Soviets just a little more than a year to copy and produce the first B-29 Superfort, after some B-29's had to make a forced landing in Siberia.[9] Innumerable Soviet technicians, production experts, and administrative groups came to the United States to examine and study the technical and productive techniques in this country.

It cannot be denied that, technically, great advancements were made by the Soviets over the war years. However, though the advancements were great, the Soviet Union finished the war about five years behind the Americans, British, and Germans; the Soviets had not developed radar, radio-controlled flying bombs, nor jet-propelled airplanes.

Postwar German Acquisitions

Even before the war had ended, the Soviets had begun to take advantage of captured German facilities and equipment. By the time the war was over, they were well on the way toward appropriating German developments, designs, and research data, as well as German technical personnel and scientists, and more than two thirds of the German aircraft production facilities.[10] Actually, these plants represent only a small portion of the aeronautical acquisitions that were obtained by the Russians from the Germans. Under the exchange of information agreements, which were in existence immediately after the war, the Soviets received documented reports of all the German research and development projects from the Western Allies; the Soviets also received verbatim reports of the interrogations of German scientists and engineers. The latter reports included most of the recommendations for further advanced developments in aircraft, rockets, and missiles.

Aircraft: At the end of the war, numerous aircraft and prototypes were obtained from the Germans. By 1944, the Heinkel-162 had been developed: this airplane was a low-cost jet fighter, equipped with a BMW-003 turbojet of 1,760 pounds thrust, and was capable of speeds up to 520 miles per hour. Early in the war, Messerschmitt and Lippisch designed the Messerschmitt-163, a rocket-powered tailless interceptor; this craft was officially clocked at 665 miles per hour in 1942. The Messerschmitt-262, a twin-jet fighter, was put into quantity production at the end of 1943. With a standard engine, this craft had a speed of 540 miles per hour, and a special version, with a more powerful engine, flew over 620 miles per hour, by the end of the war. The Messerschmitt-P-1101, a swept-wing jet fighter, was in a partially completed prototype stage at the end of the war; however, the calculated maximum speed approximated 610 miles per hour at 23,000 feet altitude. Such airplanes provided the Soviets with the most advanced designs in jet and rocket-powered fighters. Similarly, such craft

as the Heinkel-111Z (a five-engined aircraft for heavy load-carrying gliders) and the Messerschmitt-264 (a four-engined, long-range bomber, capable of carrying bomb loads of 13,000 to 17,500 pounds) presented a basis for large transport and intercontinental bomber designs.

Power Plants: Before the war, most of the Soviet piston engines could be traced directly to modifications of the earlier American, British, German, and French engines. The Russians emerged from the war, however, with little hope of future aid from Great Britain and the United States. Such aid was quickly replaced with the acquisition of two German turbojet engines – the BMW-003-A2 of 1,760 pounds thrust and the Junkers Jumo-004-B4 of 1,980 pounds thrust. At the war's end, the Germans also had projects under way for two more powerful jet engines which incorporated additional improvements, such as water injection, afterburning, additional injection of fuel into the turbine, and the use of an auxiliary liquid fuel rocketjet. These projects were continued by the Soviets and, by 1950, yielded the Soviet M-018 and the M-012, with take-off static thrusts of 7,700 pounds and 6,600 pounds, respectively. Eventually, in 1947, the Soviets also obtained 30 Derwent-5 (3,500 pounds thrust) and 25 Nene (4,500 pounds thrust) jet engines from Great Britain. The latter engine, designated as the M-45, has been subject to considerable development and, by 1951, was reported to have obtained from 5,500 to 6,000 pounds thrust via water injection and afterburning.

Missiles: The guided missile projects that were obtained from the Germans by the Soviets included considerable equipment and plans for almost every missile that had been produced or was in the process of being developed. Two separate establishments were in existence at Peenemunde: one for the Air Force and one for the Army. Peenemunde West contained an airfield for testing rocket aircraft and pilotless rocket-propelled missiles. Peenemunde East was primarily concerned with component developments, such as rocket engines and control devices. From Peenemunde, the Soviets obtained all of the technical data concerning the existing development of the bifuel rockets. Similarly, both complete plans and examples of such antiaircraft rockets as the *Wasserfell, Rheintochter, Enzian,* and *Schmetterling* were obtained from Peenemunde. It is sufficient to state, perhaps, that the Soviets acquired data concerning all of the German projects from the smallest flying bomb to the Sanger Project for a satellite vehicle. What is even more important is the fact that the Soviets obtained many of the German research and development centers almost completely intact; it was only a matter of months before these centers had been reactivated to continue their work, usually with the same German personnel, under the Soviets.

Technical Man Power: When the Soviets entered Germany and took over the operation of their aeronautical research and development facilities, they enticed many of the top German technicians, engineers, and scientists to continue their work under the Russians. Some remained in Germany and others were sent to the Soviet Union, but, in general, they continued to work on the same projects that they had been working on at the end of the war. When Professor Bock decided to continue his work under the Soviets, he recruited most of his Peenemunde staff to continue as well. Dr. Baade, who was the chief engineer for Junkers, similarly recruited a large portion of his staff to continue working under the Soviet regime. These are only two examples of what happened in many of the Soviet occupied German plants and research and development centers.

American Aviation Publications

Modern Aircraft developed in the U.S.S.R. since World War II. (Top) *The La-17 is a swept-back wing fighter resembling the MiG-15.* (Center) *The Tu-75 was one of the Soviet's early answers to long-range bombing power.* (Bottom) *The Il-28-2 is a swept-back wing version of the Il-28 tactical bomber.*

Present Soviet Technological Status

It is needless to point out that the Soviet acquisitions from the Germans had a profound effect in narrowing the technological and productive gaps (which existed at the end of World War II) between the United States and Great Britain, on one hand, and the Soviet Union. Throughout the war years, the allied nations concentrated primarily on the production of aircraft rather than on research, development, and new aeronautical designs. The Germans, on the other hand, placed a great emphasis on new designs, research, and development work – sometimes carrying out schemes bordering on phantasm. Perhaps it was a quirk of fate that caused most of the German work to fall into Soviet hands; nevertheless, the fact remains that such was the case. In any event, the gap in the technological accomplishments between the Soviet Union and the Western nations was greatly reduced.

The Soviets, who have long been experimenting with rockets, have reaped untold profits from the Peenemunde Research Center. The La-17, a swept-back wing fighter resembling the MiG-15; the MiG-15; the Il-28-2, a swept-back wing light jet-bomber; and the Tu-75, a six-engined intercontinental bomber – not to mention the more recent craft – compare quite favorably with the modern American and British airplanes. Both aerodynamically and structurally, these airplanes incorporate comparatively recent scientific progress. The power plant and armament of the MiG-15 appear to be equal, if not superior, to those of its American contemporary, the F-86. Its maneuverability exceeds that of the F-86; however, this is at the expense of other safety measurements to the pilot (armor plate, ejection seat, and so on). But the above-mentioned aircraft are only those which have been displayed, in one form or another, to the Western powers. There are undoubtedly more advanced models than have been seen over Korea and the satellite countries.

In conclusion, it appears that aeronautical technology in the U.S.S.R. has progressed at a rate far in excess of all normal expectations. There is sufficient reason to assume that any aero-technological gap which once existed between the U.S.S.R. and the Western powers is all but closed. Therefore, in order to maintain a reasonable balance of air power, it remains a necessity that the present emphasis on aero research and development be, at the very least, maintained and, more realistically, increased.

Addenda

1. At 28, Tupolev gave up a successful career in mechanical engineering to study aero and hydrodynamics at the Moscow Superior Technical School. Later, in 1910, he designed motor torpedo boats for the Czar's navy. In 1918, he and Professor Zhukovski founded the Central Aerodynamics and Hydrodynamics Research Institute which literally initiated the Soviet aircraft industry.

2. Both the German and British influences were reflected in the large emphasis on the future capacities and abilities of floatplanes; this induced a high percentage (much greater than was otherwise warranted) of seaplane production during these early years.

3. S. A. Lavochkin was born in Smolensk in 1900 of orthodox Jewish parentage. Soon after entering high school, he entered the revolutionary army. Upon his release from the army, he entered a technical high school in Moscow, where he studied under Professor Zhukovski. Though his first 10 years were devoted to structural and production details for the better-known designers, during the purge trials he combined forces with Gorbunov and Gudkov to produce the LaGG series of aircraft. He later designed the La-5 which was largely responsible for saving Stalingrad from the oncoming German forces. After World War II, Lavochkin was chosen to extract information from, and work with, the captured German aeronautical scientists.

4. The initial LaGG series of craft were low wing, single-engined, single-seated fighters and fighter-bombers.

5. A. I. Mikoyan was born in 1899 in Soviet Armenia, the son of a country schoolmaster who was also a confirmed revolutionary. Though his early life was centered about art and music, he was trained as a draftsman. He acquired an interest in aviation while working on the design of hangars and airfields and, in his mid-twenties, he attended the Moscow Superior Technical School where he specialized in aerodynamics. Upon his graduation, he was sent to the ZAGI plant in Kazan. Eventually, Mikoyan teamed up with Gurevich to produce the MiG-1. After the war, this team broke up and Mikoyan more recently gained prominence with the design of the MiG-15. He is presently, perhaps, the leading Soviet fighter aircraft designer.

6. M. I. Gurevich is reportedly an excellent mathematician and one of the leading aircraft structures men in the U.S.S.R. Little is known concerning his background except for his connection with Mikoyan during World War II. Since the war, this team has disbanded and both Gurevich and Mikoyan are designing their own aircraft.

7. S. V. Ilyushin was born in 1894, the son of a landless peasant. At 15, he obtained work as a laborer at a Moscow airfield. Three years later Ilyushin entered the military service where he learned to read and write; he soon became a mechanic and transferred to the Imperial Russian Air Force. After the revolution, he served as the chief mechanic for the Zhukovski Air Academy, studying in his spare time. In 1926, he obtained his engineer's degree and then worked at ZAGI under Tupolev. He was eventually transferred to the Air Force experimental factory near Moscow, as an inspecting engineer: he later became the head of this establishment. The Ilyushin aircraft designs reflect a great appreciation for simplicity; this was readily apparent in the Il-2, the most (numerically) produced Soviet aircraft during World War II.

8. A. S. Yakovlev is one of the most brilliant aircraft designers in the Soviet Union. He was born in Moscow in 1906, the son of a railroad repair shop machinist. At 14, he attempted to use compressed air power plants and he pioneered in the building of gasoline engines for model aircraft. In 1926, Yakovlev entered the Zhukovski Air Academy in Moscow where he came under the influence of A. N. Tupolev. His first original work was a primary glider, which he built at the age of 18. He continued to build many airplanes but was treated as a junior member of the aviation industry until, in 1936, one of his special designs won a reliability tour. At 34, in 1940, he was elevated to a position of chief engineer; this appointment, it seems, made him work with even greater intensity and since that time, he has produced an unbelievable number of aircraft.

9. Near the end of the war, three American B-29 Superfortresses, back from a raid on Japan, made a forced landing in Siberia. Though the American government demanded the return of both the crews and equipment, only the crews were returned. Tupolev, at the time, was working on the design of a long-range bomber; he was forced to give up his own design and supervise the copying of the B-29, which came to be known as the Tu-4.

10. Over 68 per cent of the German aircraft producing facilities, at the end of the war, were located in the Soviet occupied territories; the Soviets obtained facilities from the Germans to produce well over 25,000 aircraft annually. Of the German airframe producing plants, the present Soviet occupied territory includes 63 per cent of the total German plants that produced pursuits and fighters in 1944, 91 per cent of the total German plants that produced light and medium bombers in 1944, almost 98 per cent of the total German plants that produced heavy bombers in 1944, and about 73 per cent of the total German plants that produced other miscelleanous types of airplanes (trainers, observation craft, and so on) in 1944. These figures have been obtained from the German Air Ministry and are further broken down in the U.S. Strategic Bombing Survey Report.

A Place for Gladness

An Address Delivered to the Class of 1929

at Its Twenty-Fifth Year Reunion

By ERWIN H. SCHELL

MANY years ago, when my daughter was a small child, she hit upon the idea of issuing a weekly neighborhood newspaper. Among other requirements, it developed that I was to supply each issue with what was hoped to be a funny story.

This, I recall, proved a difficult task. Of my many attempts, I remember only one. It had to do with a little girl whose Teddy bear became rather the worse for affectionate wear and tear. In fact, one bright button eye became so wobbly in its cloth socket that serious surgical necessities were indicated. When her mother expressed sympathy, the little girl responded:

"Oh, it's all right. I'm going to name him Gladly."

"A strange name, indeed," said the mother; but daughter demurred: "Not at all. We sing about him every Sunday in Sunday School. Don't you remember the hymn that tells about *Gladly the cross-eyed bear?*"

My interest at the moment is certainly not in bears, whether cross- or wall-eyed. Nor am I directly concerned with gladness as an abstract virtue; for I think we all agree on this point. But I am interested and anxious that we find a place in our daily rounds for a kind of inner elation that feeds us no less than bread or even bread and wine.

Why do we come back to reunions? There is a very old saying which for generations has been used when we shake hands with one another. We say, "Glad to meet you." We return to reunions because we look forward to being with old friends, to seeing again those faces that were a part of our daily world in earlier years, to basking in the emotional sunshine, in the fair weather, which always inheres when good fellows get together. We are truly glad to meet each other again.

Of course we should not and do not look forward to a life of eternal reunions. Like the vanilla in the ice cream, reunions, when at their best, add from time to time a flavor to our existence that nothing else may replace. Here, it seems to me, lies one of the characteristics of gladness that we may well keep in mind if we are to live our lives fully. In this extraordinary gift which we speak of as consciousness we have areas of awareness which relate to our work, to our play, to our home, to our social world, and to our religious observances, to name only a few. While we are always aware that each region of interest exists, yet we can be preoccupied with but one at a time. Nevertheless, if any of these offers us cause for elation, we may turn to it momentarily with warmth and satisfaction, irrespective of our immediate preoccupation and thus enjoy its brief incursion into our consciousness.

This privilege is, I think, the reason that men enjoy having pictures of their families on their desks. As we proceed through our working day, a glance may bring to the surface of our consciousness a sense of gladness and gratitude for the satisfactions thus symbolized.

An industrialist of my acquaintance has always given prizes of permanent value to his employees. He explained:

"I want that man's achievement to remain constantly before him so that no matter how hard the going, he may always recall and be inspired by his earlier accomplishment."

This, I suppose, is why many countries still maintain a royal family which reigns rather than rules and which, when at its best, provides cause for widespread elation in an otherwise dreary political world. Witness, for example, the extraordinary outpouring of gladness as Queen Elizabeth stood before the people of her Commonwealth on her recent world tour.

May I suggest some ways in which we may cultivate and increase in our lives those moments which bring a sense of elation.

Elation of Accomplishment

The first has to do with accomplishment itself. I am convinced that we do not ordinarily allow ourselves the self-earned gratifications that our accomplishments deserve. We are too inclined to brush away our success in a gesture of over-modesty, saying, "Oh well, that didn't amount to much."

The truth is that it is our successes that keep kicking us upstairs. Many are the examples of men who attained far greater eminence than they ever originally anticipated, largely because the stimulus of their successes urged them forward to ever greater efforts. I may be misunderstood when I say that we owe it to our own futures purposely to revel with uninhibited enjoyment in our achievements — not publicly, of course, but so that we may taste to the full the sweet nectar of hard-earned accomplishment.

Years ago when George Bernard Shaw was returning to England from America, he was observed on shipboard reading a book that filled him with great amusement. So curious did one passenger become that he contrived to look over Shaw's shoulder at the title of the volume. It proved to be one of the earlier writings of George Bernard Shaw!

Elation from Examples of Others

Next, I would urge the cultivation of an active pride in, and admiration of, other people, their attainments and their standards. We say to ourselves: "There is a fine person — there is an inspiring personality" and we return with fresh resource to the work at hand.

I have a friend who for many years has purposely drawn emotional sustenance from his wide acquaintance with people of solid character and accomplishment. His self-initiated correspondence, conversations and conferences with people of merit have provided him with a never-ending flow of personal inspiration and pleasure. He has literally built resources of constructive gratification into his life.

In a letter, after telling of his early acquaintance with Carnegie, Wanamaker, and Flagler, he went on to say:

"I could tell of other great personalities who have influenced me. Schweitzer, Grenfell, Gandhi, Nehru, Hoover, Coolidge, Al Smith, Billy Sunday, Charles Lindbergh. Meeting these people had an effect upon my character. Meeting them accidentally? No. These meetings were carefully planned."

Awareness of Beauty

A noted architect once addressed our class on the subject of aesthetics in industry. His final words were to this effect:

"Love beauty, wherever you may find it, whether in Nature, in man's handiwork, or in people themselves. It will add joy to your day and happiness to your life."

I have long enjoyed the taking of colored motion pictures. To my surprise I discovered that the mere carrying of a color camera increased my sensitiveness to the presence of hue and shade. I have found this increased perceptiveness to be an unanticipated resource and delight.

There is the story of the kindergarten teacher in the slum area of a large city. She had talked to her small charges about the presence of beauty in the world but the going was hard. Few could think of illustrations. So, in desperation, she asked the children to bring to school one example of something in their homes that they had seen and enjoyed. The next morning, hands were few when she called for responses. Finally, one mite spoke up:

"Teacher, I went home and looked like you said. I looked on the second floor — I saw nothing; I looked on the first floor — I saw nothing; I went down to the dark cellar. There was my baby sister playing in the dirt. There was a little hole in the bricks in the wall behind her. There was a sunbeam coming through the hole, and it shone right on my sister's red, red hair down in that dark cellar, and I tell you, teacher, it was beautiful." Beauty can lift us up.

Anticipation

All of us benefit if we have something in the nature of a happy event to look forward to. While we may find enjoyment in doing pleasant things on the spur of the moment, there are many of us whose hearts are gladdened by the thought of that which is to come. Next week's theater tickets on the living-room table; a road map engrossed with a future peregrination, the early perusing of a spring flower catalogue — all add verve and flavor to our existence. With but normal forethought and effort we can constantly have before us some enjoyable event-to-be — the thought of which, as our working day proceeds, on its course, brings a lift.

Even when anticipation is built upon uncertainties, its power may be great. I have always enjoyed a story my father used to tell about a man from the old country who bought a tenth of a $10,000 lottery ticket. Around the dinner table at night, the family discussed the possibilities thus offered to them. What would they buy? The head of the family quickly put a stop to such alternatives. In his own mind he had already made a decision which he thought would please his family, as well as himself.

"I will buy an automobile," said he. "And, I will soon learn to drive and we will all go every Sunday into the country. And my wife Olga will sit beside me in the front seat and little Olga and Hans will sit in the back seat . . ."

"No, father," from little Hans, "I want to sit in the front seat."

"Hans sits on the back seat."

"But, father, how can I learn to drive if I sit on the back seat?"

"There is plenty of time, Hans, for you to learn to drive."

"But, father, I want to learn to drive *now*."

"Hans Hopfalfinger—*get out of the car!*"

Satisfactions to Order

I suppose there is no medium for made-to-order elation more powerful than the hobby. Short-term accomplishments and their ensuing lift can almost be designed to measure. At times our daily work may not yield an immediate thrill of satisfaction. Then we may turn to our avocation — be it golf, stamp collecting, or the basement workshop — for those more immediate satisfactions which bring pleasure when we think of them.

I listened one evening to the proprietor of a training center for "hobby-crafters" as he told of his experiences in the development of avocational skills.

"Take copper-smithing, for example," he said. "A man comes in — wants to learn copper-smithing. We give him a rectangular wooden block with a shallow circular indenture a few inches in diameter in the center. We give him a circular piece of sheet copper that fits over the round area. We give him a peening hammer and tell him to hammer hell out of the copper. He turns to, and in half an hour he takes out his piece of copper and finds he has an ash-tray. This delights him no end.

"The next week we give him something that takes an hour's work before it is completed. And so on until he is ready to spend thirty, forty, or fifty hours on a project that results in something that really gives him a terrific psychic boost."

(*Concluded on page 46*)

Science for the Good of Mankind

President Killian's Report to the Corporation

Emphasizes Beneficent Uses of Science

At its annual meeting on October 4, the Corporation of M.I.T. expressed its deep sense of loss in the death of its chairman, Karl Taylor Compton, paid tribute to his long and able leadership, and voted that its resolution on Dr. Compton be made part of the permanent record of M.I.T. Prepared by a committee whose members were Vannevar Bush, '16, James R. Killian, Jr., '26, Alfred L. Loomis, and Gerard Swope, '95, the resolution on Dr. Compton appeared on the opening page of the President's Report to the Corporation.*

In opening his thought-provoking annual message to the Corporation, President Killian recalled that the most insistent and commanding intellectual problem of our time is that of survival, and defense of the free world against sustained ideological assault and possible thermonuclear attack. In calling for the continued advance of the beneficent uses of science, President Killian remarked:

> One of the many requirements imposed upon the nation by this brutal fact is an inescapable demand upon scholars and educational institutions to serve the national defense and to strengthen the free world. In this marshaling of the creative resources of scholarship, science and technology occupy a position of great responsibility and difficulty: for out of science have and must come some of the major instrumentalities for the strengthening and the protection of the free world. This may well be one of the most beneficent current services of science and scholarship. . . .

After reviewing briefly the growth of private and federally supported research, the present heavy demand for scientifically trained personnel, the need to strengthen and preserve the freedom of private institutions, and the increased responsibility of institutions of higher learning, President Killian remarked:

> Along with the growing recognition of the importance of science to the national welfare have appeared adverse reactions to science – reactions of fear, uneasiness and misunderstanding, especially with respect to the work and methods of the scientist. The great and frequently dramatic part that science plays in our defense has resulted in a tendency to identify science mainly with military applications and to think of its effects in terms of destruction. There has been a growing danger that the beneficent values of science would be clouded by these fears and misunderstandings, and recent events have clearly pointed up this hazard.
>
> One of the responsibilities of M.I.T. in the light of these current conditions is to explain, to demonstrate and to symbolize the beneficent nature of science and of creative intelligence. While discharging to the level best of our ability our responsibilities for defense, we must also keep steadily before us the importance of providing a favorable environment for pure research, for the prospering of disinterested curiosity, for the pursuit of science as a noble end in itself and for the encouragement of creative intelligence.
>
> If American science is to continue to prosper, if it is to continue to attract to it its proper complement of creative and gifted minds, we must everywhere combat the mistaken notion that science and engineering are narrow, provincial and destructive of human values. We must demonstrate instead that science and engineering are great liberalizing, humanizing forces as well as the greatest intellectual structure achieved by our civilization, and that the spirit and outlook of science have given and continue to give strength and vigor to the character and spirit of the American people. . . .
>
> In serving the nation's safety and economy and industrial development, men of science and technology at the same time thus serve a deep spiritual need – the need to understand nature and to use it for the welfare of man. The practical benefits of science are a by-product of this urge to understand. Indeed science finds its fulfillment not only in the great practical structures it creates but also in the insights it provides into the order, the majesty and the mystery of man and of the universe. The needs of the spirit are served when we pursue science with these ends in mind – when we prize its practical benefits while keeping steadily in view the soaring structures of thought and beauty that science has slowly been building.
>
> In face of the current turmoil involving scientists and other scholars, it is our continuing responsibility and opportunity at M.I.T. to express with poise and composure the beneficent values of science and all other forms of creative intelligence and to combat the anti-intellectualism which deprecates these values. We have an unusually urgent responsibility now to stress the true character of science as a liberalizing, humanizing and creative force that serves man spiritually as well as intellectually and practically. . . .

Educational Trends

In discussing educational trends at M.I.T., President Killian reviewed the more important innovations and advances in the Institute's curriculum and teaching methods. More flexibility is being introduced in the educational process, and there is an increasing emphasis on fundamentals. For example, the Department of Physics is reorganizing its laboratory instruction for freshmen and sophomores; a new program in the Department of Electrical Engineering provides broadened and deepened scientific content; and establishment of a new course of study (whose content will be made up of approximately half engineering and half humanities and social science topics) is under investigation. The Institute's Center for International Studies provides new opportunities to prepare engineers for foreign service, particularly with

* The resolution on Dr. Compton is reproduced on page 12, as the frontispiece of this issue of The Review.

industrial firms. A clear need exists to give a larger place to psychology in our curriculum, and distinguished scholars in the field have urged creation of a Department of Psychology, when this can be adequately financed.

The present educational trend toward greater emphasis on science is perhaps best summarized in Dr. Killian's own words:

> What we are witnessing at M.I.T., along with a renaissance of imaginative teaching, is a new coalition of engineering and science, of science and social science, of education and industry and of general and professional education – a coalition designed more adequately and fully to meet the increasingly complex needs of our society, an education up to date in its outlook and relevant in its content to the needs of an industrial civilization. . . .

Already the grammar and secondary schools are pressed to meet the needs for the large number of children born during or after World War II. Soon the nation's colleges and universities will be affected by the greatly increased numbers of applicants who seek admission to college. If the institutions of higher learning are to provide the same facilities per student as they do today, it is estimated that as much college plant will have to be built in the next 15 years as has been built in the United States during the past three centuries. Naturally this anticipated increase in enrollment affects policies at M.I.T., particularly since the Institute has had limited enrollment for about two decades. On this topic President Killian reported:

> It is our present feeling that M.I.T. has many responsibilities to assume in helping to meet this national growth in college enrollments but that our primary responsibility is to maintain high standards and educational leadership. We will not be able to do this if we permit ourselves to grow too large. It is the consensus of our Faculty and administration at the present time that without a marked change in structure and a great increase in resources, we cannot grow appreciably larger in enrollment at the Institute and still maintain the standards, the leadership and the opportunity to pioneer and innovate which have always characterized M.I.T.
>
> I feel it important that we accept our share of the responsibility of meeting the impending critical shortage of teachers of science in the secondary schools and of steadily refining and advancing our own educational program for the purpose of setting standards for our kind of education throughout the country.
>
> Financially we cannot justify an increase in enrollment without increasing our permanent funds. This is particularly true if M.I.T. is to have the stability of support and the working capital required to undertake the wide range of public service it is now asked to carry. In 1940 our endowment per student was $21,000. Because the growth of our endowment has not kept pace with inflation or with increasing enrollment, this figure has dropped to $10,000, if we adjust for the changed value of the dollar. The immediate effects of greater tuition income as a result of increasing enrollment are, in the long run, illusory, because the enrollment increase invariably creates new capital requirements not immediately felt. . . .

Building and Campus

During the past five years, the Institute has gone through the largest building program since it moved to Cambridge in 1916. The value of the educational plant, at cost, was $19,500,000 in 1948; today it is more than $34,000,000. But, said Dr. Killian, "Even though we do not enlarge the size of our student body in the years ahead, we will still need additional facilities to round out our program." Obsolescence of educational facilities in science and engineering – greater than in other disciplines – brings with it the urgent problem of keeping up to date.

But new facilities are also needed. Among those mentioned in President Killian's report are an adequate Student Union and Alumni Center, permanent houses for the continuing large number of married students, and much improved parking facilities. New facilities for nuclear science and electronics have been urgently needed for many years. In reporting progress toward meeting the need for properly housing research activities in these fields, Dr. Killian said:

> For the past five years the top priority given any physical need of the Institute has been a building to bring together our teaching and research facilities in electronics and in nuclear science, which are now widely scattered and atrociously housed in temporary buildings built for wartime activities. At commencement I announced the decision of our Executive Committee to undertake a concentrated special gifts campaign to build this building, and in addition to build an unclassified nuclear reactor for educational use.
>
> The last Executive Committee meeting over which Dr. Compton presided authorized this effort, and he advocated the program with enthusiasm and a sense of urgency. Following Dr. Compton's death Alfred P. Sloan, Jr. '95, and then others independently proposed that the nuclear science and electronics laboratory be built as a memorial to Dr. Compton.
>
> Under the joint leadership of Mr. Sloan and of Marshall B. Dalton '15, its honorary chairman and chairman, respectively, the Development Committee of the Corporation is actively planning the campaign to provide capital and operating funds for these two facilities.
>
> Among the many reasons leading to the decision to build an unclassified nuclear reactor is the conviction that the development of atomic energy for beneficent use is important to the spirit of America. Though we must build bombs in a world out of joint, we will move ahead into a better time only by improving the lot of mankind and addressing ourselves to more noble ends than atomic might. The use of science for defense is necessary and we cannot be strong without it. But such use of science and technology is not a natural or satisfying use and in the end can only thwart and distort their true spirit. Is it not possible that bold and imaginative acts by Americans to demonstrate the moral purpose and the nonmilitary uses of science and technology can contribute to our own reassurance and to our leadership of a world seeking peace? Our great resources of intelligence, imagination, ingenuity and risk-taking spirit are moral forces that can lead a world out of a cold war. Science, with its spirit of creativity, its search for understanding, its dependence upon freedom and good will and its world-wide currency, offers an avenue to a higher standard of living for all the world, but more importantly, to a resurgence of a spirit of reconciliation and good will among nations. In this period of cold war we are engaged not only in an atomic armaments race but in a race to apply atomic energy to peaceful and beneficial use. This is a race we must win not only for our own welfare but for our influence in the community of the free world. . . .

(*Continued on page 47*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Den Hartog Heads Course II

APPOINTMENT of Jacob P. Den Hartog as Head of the Institute's Department of Mechanical Engineering was announced during the summer by C. Richard Soderberg, '20, Dean of the School of Engineering at M.I.T. Professor Den Hartog has been in charge of the Division of Applied Mechanics of the Department he now heads, since 1945, and is regarded as one of the world's foremost authorities in the field of mechanical vibrations.

A graduate of Delft Technical School in Holland (in 1924), Professor Den Hartog received the degree of doctor of philosophy from the University of Pittsburgh in 1929. During 1930–1931 he studied hydrodynamics and aerodynamics under Professor Prandtl at the University of Göttingen in Germany.

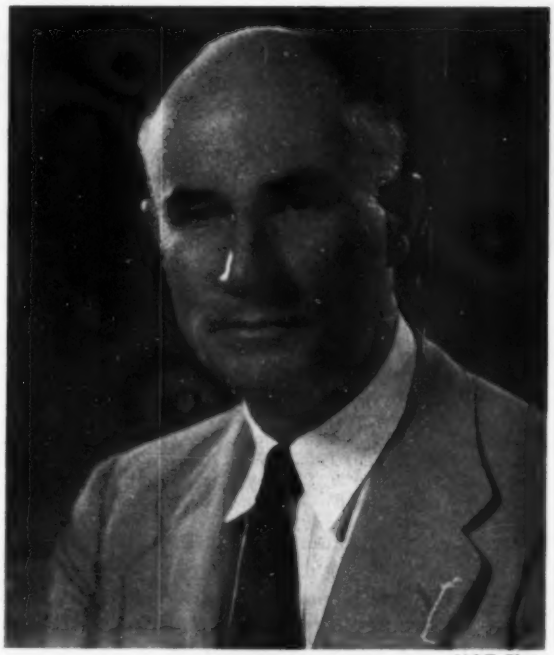
Except for the year at Göttingen, from 1925–1932 he was associated with the Research Laboratory of the Westinghouse Electric Corporation in Pittsburgh, where he served in the Mechanics Division specializing in problems in dynamics and mechanical vibrations. In 1932 he joined the engineering faculty at Harvard where he served as assistant professor of applied mechanics from 1932–1936 and as associate professor from 1936–1941. In 1942 Harvard awarded him the honorary degree of master of arts.

Born in Ambarawa, Java (Indonesia), Dr. Den Hartog became a naturalized United States citizen in 1930 and in 1939 received a commission in the United States Naval Reserve. During World War II (1941–1945) he served with the Navy on assignment with the Bureau of Ships, where he contributed to the solution of many problems of vibrations and participated in the trials of nearly all of the larger vessels. In 1945, while he was a member of the U.S. Naval Technical Mission investigating German war industry and research, he was appointed captain in the U.S. Naval Reserve.

Dr. Den Hartog has been a recipient of many professional honors, among them the Richards Memorial Award, which he received in 1947 for "outstanding work in applied mechanics," and the Worcester Reed Warner Medal, which he received in 1951 for "outstanding contributions to engineering literature."

A fellow of the Institute of the Aeronautical Sciences and of the American Academy of Arts and Sciences, Professor Den Hartog is also a member of the National Academy of Science, the American Society of Mechanical Engineers, the American Society of Naval Engineers, the American Society for Engineering Education, Sigma Xi, Tau Beta Pi, and Pi Tau Sigma.

Professor Den Hartog is the author of numerous articles in the technical press and of the highly regarded text *Mechanical Vibrations*, which is now in its third edition and which has appeared in French, German, and Russian translations.



M.I.T. Photo

Professor Jacob P. Den Hartog
Head, M.I.T. Department of Mechanical Engineering

His other books include *Mechanics, Strength of Materials,* and *Advanced Strength of Materials.* He is also co-editor of the *Transactions of the Fifth International Congress for Applied Mechanics,* and author of a section of Marks's *Mechanical Engineers' Handbook* (3d, 4th, and 5th editions).

Professor of Acoustics

THE appointment of Richard H. Bolt as Professor of Acoustics in the Department of Electrical Engineering was announced on September 19 by C. Richard Soderberg, '20, Dean of the School of Engineering. Dr. Bolt has been director of the interdepartmental Acoustics Laboratory at M.I.T. since 1946, and is one of the unquestioned leaders in the field of acoustics not only in the United States but also internationally.

"The acoustic requirements of modern architecture, the increasing tempo of industry, the larger size of many industrial tools, and the disturbance to civilian activity of jet aircraft breaking the sound barrier are examples which make scientists and engineers very conscious of noise and its detrimental effect on human beings," said Dean Soderberg. He added that Dr. Bolt's new appointment as Professor of Acoustics in the Department of Electrical Engineering and his continuing assignment as director of the Acoustics Laboratory suggest M.I.T.'s response to this increasing problem.

Fay Foto

Pictured above and on the facing page are 76 of the 83 members of the Class of 1904 and their wives who celebrated the 50th reunion of the Class on Cape Cod last June. Shown above on this page, in the first row, seated on the ground, in usual reading order are: Carle R. Hayward, Karl E. Peiler, Paul McC. Paine, Amasa M. Holcombe, Frank J. Severy, Bernard Blum, and E. Farnum Rockwood. Second row, seated in chairs: George Ainsworth, Arthur P. Porter, Mrs. Arthur P. Porter, Mrs. William G. H. Whitaker, Jr., Mrs. Guy P. Palmer, Mrs. Currier Lang, Mrs. Walter E. Hadley, Mrs. William S. Anthony, Mrs. Arthur H. Langley, Mrs. Karl E. Peiler, Mrs. Paul McC. Paine, Henry K. Richardson, Mrs. Amasa M. Holcombe, Mrs. Frank J. Severy, Mrs. Eugene H. Russell, Jr., Mrs. Bernard Blum, Mrs. Harry T. Rollins, and Mrs. E. Farnum Rockwood. Standing, in the third row, are: Robert B. Sosman, Robert Palmer, Mrs. Robert Palmer, Mrs. Harry H. Groves, Harry H. Groves, Guy P. Palmer, Currier Lang, Walter E. Hadley, Arthur H. Langley, Mrs. Carle R. Hayward, Eugene H. Russell, Jr., Edward F. Parker, William G. H. Whitaker, Jr., Louis H. G. Bouscaren, Arthur D. Smith, Harry T. Rollins, David Sutton, and Mrs. David Sutton.

At M.I.T., the Departments of Architecture, Electrical Engineering, and Physics participate jointly in the Acoustics Laboratory, bringing to its work the problems and experience of both theory and practice.

Dr. Bolt was graduated from the University of California in 1933, having majored in architecture.

M.I.T. Photo

Richard H. Bolt

Professor of Acoustics, Department of Electrical Engineering

Following his graduation he undertook intensive training in acoustics and physics at the same institution, received a master's degree in physics in 1937, and was University Fellow until 1939 when he was awarded the doctor of philosophy degree.

Following an interesting career as a National Research Fellow, Dr. Bolt joined the acoustics staff at M.I.T., working under the supervision of Professor Philip M. Morse of the Department of Physics. In 1943 he was sent to London, assigned to the Office of Scientific Research and Development; subsequently he became chief technical aide to the National Defense Research Committee, Division 6, New York. He joined the faculty of the Department of Physics in 1945 and became an associate professor of physics in 1946.

Dr. Bolt went to England in 1947 to survey research on underwater sound for the National Research Council as a member of the Undersea Warfare Committee's Acoustics Panel. He also attended the Marconi Congress at Rome as a delegate of the American Institute of Physics and the Acoustical Society of America. In 1949 he delivered a series of lectures on room acoustics at the Royal Institution in London and advised the London County Council on the acoustic design of the Royal Festival Hall.

Dr. Bolt is a member of the American Institute of Physics and served on its Policy Committee from 1945 to 1948. He is a fellow of the Physical Society, the American Association for the Advancement of Science, and the Acoustical Society of America of which he was president in 1948–1949. He is currently president of the International Commission on Acoustics and chairman, Armed Forces National Research Council committee on hearing and bio-acoustics.

Fay Foto

Continuing with the names of the participants who attended the 50th reunion of the Class of 1904 at the Oyster Harbors Club in Osterville on the week end of June 11, from the above illustration we list (first row, seated on the ground, reading from left to right): E. Farnum Rockwood, William B. Boggs, Clarence B. Williams, Frank H. Davis, Everett O. Hiller, and Robert M. Phinney. Second Row, seated in chairs: Mrs. Harry T. Rollins, Mrs. E. Farnum Rockwood, Mrs. William B. Boggs, Mrs. Clarence B. Williams, Mrs. Charles R. Haynes, Mrs. Frank H. Davis, Mrs. Elmer A. Holbrook, Mrs. Everett O. Hiller, Mrs. Robert M. Phinney, Mrs. Alfred L. Coupe, Mrs. Harry H. Needham, Mrs. George K. Kaiser, Henry W. Stevens, Mrs. Charles J. Emerson, and Mrs. Simon J. Martenet. In the back row, standing, are: David Sutton, Mrs. David Sutton, Mrs. Cyrus Y. Ferris, Cyrus Y. Ferris, Charles R. Haynes, Otis D. Fellows, Mrs. Henry W. Stevens, August W. Munster, Elmer A. Holbrook, George A. Curtis, Harry S. Kendall, Alfred L. Coupe, Harry H. Needham, George K. Kaiser, Frank W. Milliken, Charles J. Emerson, and Simon J. Martenet. The reunion culminated in the Alumni Day program on June 14 in Cambridge.

Science Research Laboratories to Rise as Memorial to Dr. Compton

New laboratories dedicated to the fundamental research which will exploit the vast peacetime potential of electronic and nuclear science will be built as M.I.T.'s memorial to the Institute's late chairman, Karl Taylor Compton. Speaking at an Institute-wide convocation in commemoration of Dr. Compton on October 4, James R. Killian, Jr., '26, President, announced plans for building the Karl Taylor Compton Laboratories for Nuclear Science and Electronics.

Preliminary drawings for a $3,000,000 building have already been made by Skidmore, Owings and Merrill, architects of New York. In addition, Dr. Killian announced, a fund of $3,000,000 will be provided for unrestricted support of the Institute's work in these fields.

M.I.T.'s nuclear reactor, to be devoted solely to education and nonsecret research in the peactime applications of nuclear power – plans for which were announced at the Institute's commencement last June – will also be associated with the Karl Taylor Compton Laboratories.

The proposed laboratory building to honor Dr. Compton will comprise about 125,000 square feet of floor area, designed especially for M.I.T.'s work in nuclear science, nuclear engineering, and electronics – and related activities under the Departments of Physics, Electrical Engineering, and Chemical Engineering. "Much of the most important and significant education and research in these physical sciences since World War II," Dr. Killian said, "has been carried out at M.I.T. in grossly inadequate temporary buildings which were erected for urgent research during the war."

In these plans, Dr. Killian said, the Institute has the full and enthusiastic support of the M.I.T. Corporation's Committee on Development, headed by Alfred P. Sloan, Jr., '95, chairman of the Board of General Motors. Dr. Killian recalled that, at the last meeting of the Executive Committee over which he presided before his death, Dr. Compton enthusiastically supported the preliminary plans for a physical sciences building and a nuclear reactor devoted to peacetime objectives. "Because of his belief in the importance to education and science of these two facilities, it is singularly appropriate that they should bear his name," Dr. Killian declared. "No greater need for facilities exists at M.I.T. today than for adequate permanent laboratory space for the physical sciences."

"Dr. Karl Compton, by his imagination and efforts," Mr. Sloan has written, "developed the Massachusetts Institute of Technology into one of the leading – if not the leading – scientific institutions of our time, a real asset to our whole society. He felt strongly that to maintain the leadership of the Institute required an aggressive and imaginative program which would, while serving M.I.T.'s interests, support tremendously our scientific advancement as a whole."

The 1955 Alumni Fund will be devoted exclusively to this memorial to Dr. Compton, it was announced in October in behalf of Theodore T. Miller, '22, chairman of the Alumni Fund Board and Vice-president of the Dewey and Almy Chemical Company. "We are confident," he said, "that M.I.T. alumni everywhere will welcome this expression of their affection and high regard for one of the Institute's greatest leaders."

Herbert Stier

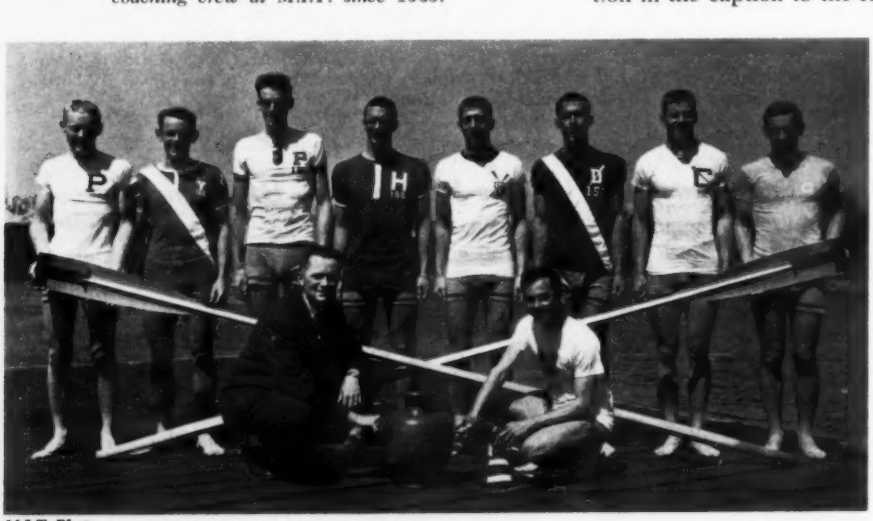
Emblematic of M.I.T.'s victory in the Henley Regatta is the Thames Challenge Cup proudly displayed by crew leaders at the Institute. Left to right are Ivan J. Geiger, Director of Athletics, James B. McMillin, '43, Coach, William H. McTigue, Jr., '54, captain, and Ward Evis, rigger. Mr. McMillin has been coaching crew at M.I.T. since 1939.

M.I.T. Wins Thames Challenge Cup

ALTHOUGH briefly reported in the July, 1954, issue of The Review (page 478) the success of the M.I.T. 150-pound crew in winning the Thames Challenge Cup on July 3 can now be substantiated by photographs. To win the British regatta trophy from the Royal Navy at Henley-on-Thames, the M.I.T. crew successively rowed against, and beat, able crews from University College, Reading University, London Rowing Club, Thames Rowing Club, and the Royal Navy.

The victory was a great event for members of the Institute's crew, for James R. Killian, Jr., '26, President, and for Ivan J. Geiger, Director of Athletics, who were present for the races. But perhaps the trophy, and the victory it represented, meant most to James B. McMillin, crew coach at M.I.T.

The photograph at the left shows the principals in the crew race, with the Thames Challenge Cup about to begin its air trip to the United States. Members of the victorious crew are shown below, with identification in the caption to the right of the illustration.



M.I.T. Photo

"Victory shirts" won on May 15, 1954, at the 150# Intercollegiate Regatta at Princeton. The shirts, left to right, are from: Pennsylvania, Yale, Princeton, Harvard, Navy, Dartmouth, Cornell, and Columbia. The oarsmen, in the usual reading order, are: Valdemar A. Skov, '55, Robert F. Buntschuh, '55, William H. McTigue, Jr., '54, Robert N. Sawyer, '56, Gordon J. Burrer, Jr., '55, F. Lawrence Holmes, '54, Leonard V. Gallagher, '54, and Robert D. Wilkes, '55. In front, holding the Joseph Wright Trophy, are Jack H. Frailey, '44, coach, and Jerome D. Waye, '54, coxswain.

Pictured below is the M.I.T. crew pulling to victory over the British Royal Navy boat at Henley-on-Thames. Seventy-two crews were contestants for the Thames Challenge Cup which was annexed by M.I.T. in the final competition on July 3. At the finish, Coxswain Waye was tossed in the river in the traditional manner.

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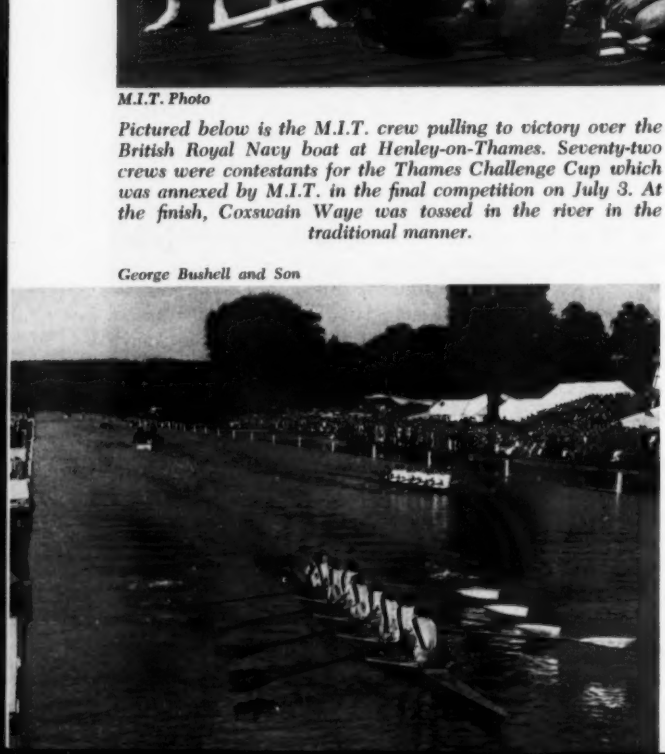

M.I.T. Has Largest Freshman Class

THE largest freshman class in the history of M.I.T. arrived at the Institute on September 16 for traditional Freshman Week End activities. Registration of more than 950 entering students inaugurated a busy four-day week end designed to acquaint the new freshmen with campus and classroom life at the Institute.

High light of the program for new students was an address of welcome by James R. Killian, Jr., '26, President of the Institute. E. Francis Bowditch, Dean of Students, and Eldon H. Reiley, '55, President of the undergraduate governing body at M.I.T., also addressed the group.

In his address to the freshmen, President Killian emphasized the spiritual, as well as the intellectual, growth which M.I.T. offers:

"While serving the nation's economy and safety, men of technology must also serve man's need for

(*Continued on page 36*)

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Time thus was reduced by some six hours. Argon consumption was cut to about 25 cubic feet at a cost of about $3, representing a saving of about $23 in gas alone. Cost estimates of the two processes indicated a total saving of about $50 per tube sheet. Since the manufacturer still had over one hundred of these heat exchangers to make before the contract was completed, total savings will amount to about $5,000, as a result of the better method.

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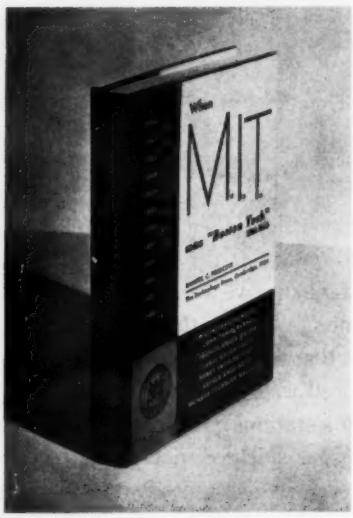

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THE INSTITUTE GAZETTE

(*Continued from page 34*)

understanding and for spiritual growth. Here at M.I.T. we can give a pilot-plant demonstration that men and women may live and work together with a minimum of meanness and irresponsibility and with a conscious effort to utilize reconciliation and good will to advance the lot of each other.

"We have an opportunity to exemplify day in and day out our democratic ideals of social justice, freedom, and individual dignity. We have an obligation to resent every encroachment upon these ideals and every act which erodes away this freedom and this dignity. We have an obligation to cultivate and demonstrate the moral idealism which is the cement of our society.

"At M.I.T. we also have an inescapable responsibility to deal with ideals as well as ideas and to concern ourselves with values while we become proficient with things. To achieve this combination we have been creating at M.I.T. a new coalition of ideas and ideals, of science and social science, and of general and professional education with the intent of providing an outlook and a culture relevant to the needs of modern life. This new coalition of learning emphasizes our conviction that you can be neither an effective scientist, engineer, executive, economist, nor architect without acquiring understanding of our society and of human relationships."

The four-day program included tours, conferences, and athletic and social events which are designed to acquaint the new students with campus and classroom life at M.I.T. Other high lights included a tea for women students, an acquaintance dance, and special church services and programs. The activities were concluded with a reception on Sunday afternoon, September 19, by President and Mrs. Killian.

Harry W. Gardner: 1873–1954

HARRY W. GARDNER, '94, Professor of Architectural Design, Emeritus, who served on the faculty of the Department of Architecture for 48 years before retiring in 1943, died on July 25, 1954. He was 81 years old.

Professor Gardner was born in Dover, N.H., and joined the Institute staff as instructor in architecture one year after his graduation. He was promoted to assistant professor in 1903, associate professor in 1909, and professor of architectural design in 1920. Following his retirement, he served for one year as lecturer in the Department.

Under the Austin Fellowship, Professor Gardner studied architecture in Sicily, Italy, France, and England during 1889–1900; and four years later traveled through these countries again as conductor of a departmental summer school.

A member of the American Institute of Architects and Boston Society of Architects, Professor Gardner contributed greatly to the development of the Department of Architecture at the Institute.

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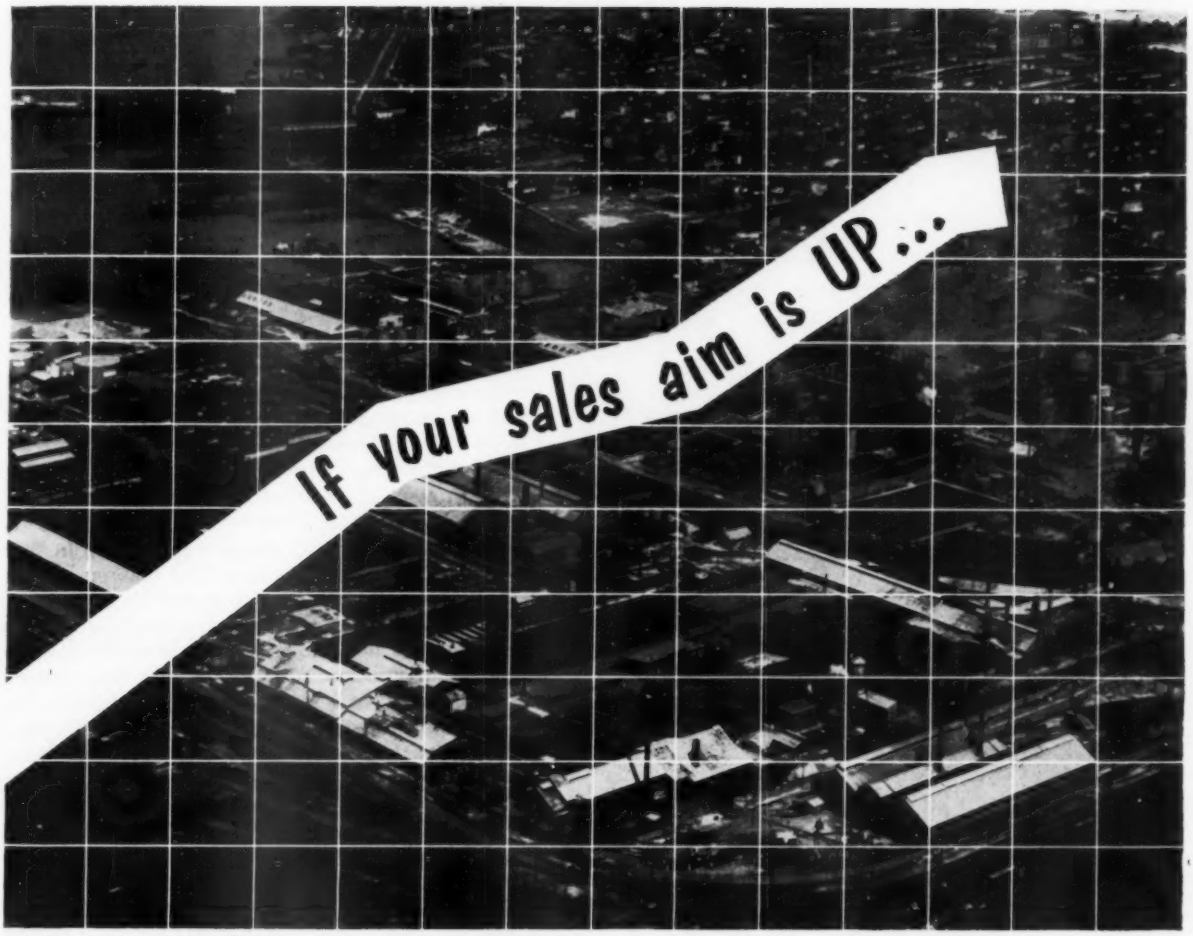

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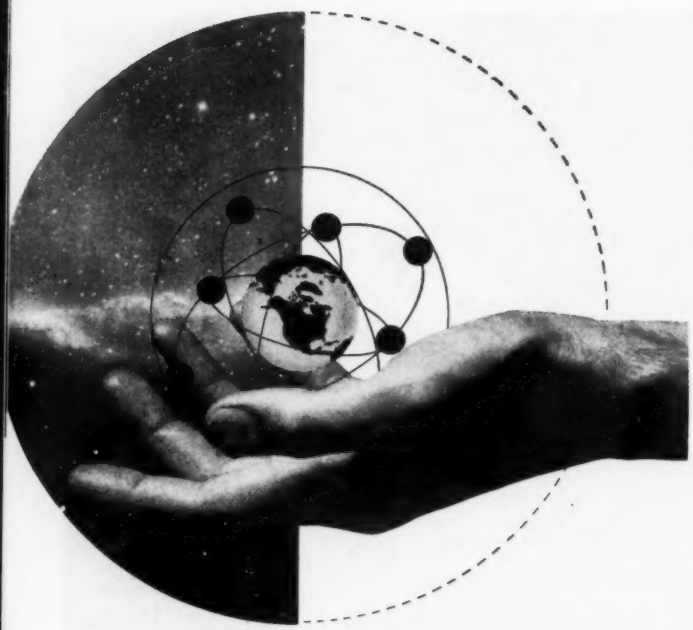

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(*Continued from page 36*)

Revised Electrical Curriculum

MEETING at the Institute for an all-day session on February 11, 1954, members of the Visiting Committee on the Department of Electrical Engineering* and members of the Department convened with James R. Killian, Jr., '26, President of the Institute, Julius A. Stratton, '23, Provost, and Edward L. Cochrane, '20, Dean of the School of Engineering, who represented the Administration.

The report of the Visiting Committee, which has been summarized below, was received for publication in The Review on June 2, 1954.

The morning was devoted to discussion with Gordon S. Brown, '31, Head of the Department of Electrical Engineering, assisted by key members of the staff who are responsible for new subjects of instruction in the revised curriculum. The new curriculum of basic subject matter in Electrical Engineering is to be offered to all students, whereas the plan of previous years had provided for options in Electric Power, Communications, and Electronic Applications.

Dr. Brown gave a brief sketch of the entire Electrical Engineering four-year curriculum as now proposed by the Departmental Committee on Educational Policy. Professor Ernst A. Guillemin, '24, Truman S. Gray, '29, Associate Professor of Engineering Electronics, Thomas F. Jones, '40, Alexander Kusko, 2–44, Samuel J. Mason, '47, David C. White, Associate Professors of Electrical Engineering, and Richard B. Adler, '43, Assistant Professor of Electrical Communications, then summarized for the Committee their objectives in each of their subjects.

The Committee found the report encouraging. Required electrical subjects in the new program will comprise both classroom and laboratory instruction, to facilitate a broad understanding of the basic fundamentals of electrical science, and the development of an awareness of the creative exploitation of these fundamentals in engineering practice. The Department places great emphasis upon the laboratory aspects of instruction, and the Committee was enthusiastic of the accomplishments in equipping and planning the circuit theory, electronic, and energy-conversion laboratories that correlate with the classroom subjects in these areas.

The aim in building the course of instruction is to preserve equal opportunity for every student with respect to his eventual choice of free electives in the senior year, and in his subsequent choice of professional work. The offerings of professional elective subjects are both broad and deep, and the student may draw upon the resources of the whole Institute in the choice of professional elective subjects and not

(*Continued on page 40*)

* Members of this Committee for 1953–1954 were: H. B. Richmond, '14, chairman, Francis J. Chesterman, '05, Thomas J. Killian, '25, Edward J. Poitras, '28, Edwin H. Armstrong (deceased), James W. McRae, Gwilym A. Price, and B. Richard Teare.

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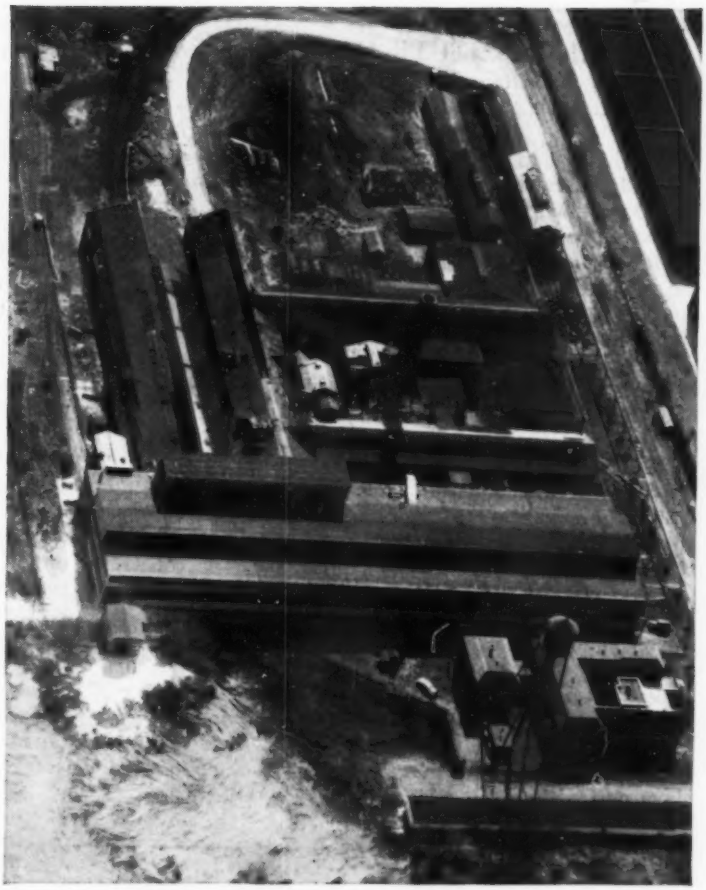
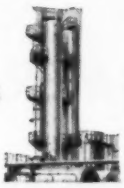
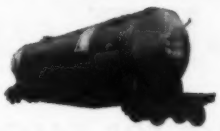


...occupying 25 acres at Edge Moor, Delaware (adjacent to Wilmington) for the manufacture

of towers  pressure vessels 

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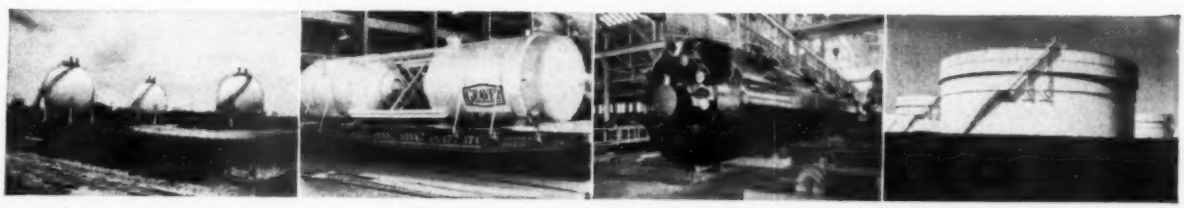

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THE INSTITUTE GAZETTE

(*Continued from page 38*)

confine himself to a choice wholly from within subjects offered by the Electrical Engineering faculty. The Department is confident that it will prepare the student to be ready for service, with excellent potential for future professional growth, in any segment of the broad field of electrical engineering, whether it be operating, manufacturing, design, or research, and without regard for the artificial boundaries established by power and frequency dimensions.

The rebuilding of the physical structure of the laboratories is progressing rapidly, with priority given to equipping the new laboratories in the circuits, electronics, and the junior-year subject on energy conversion. Reconstruction of the old machinery laboratory is under way. It has not been possible to proceed as rapidly with this phase of the effort as with the laboratories named above; first, because the present senior class [1954] needed the machinery laboratory to wind up their senior-year studies under the old program; second, because the task is difficult; and third, because major changes in plant layout are dependent upon the disposition of the Electrical Engineering Department Substation, which comprises several very large machines. Disposing of these machines on an economical basis could not be done in a short period. Related to the substation problem has been the disposition of the network analyzer. The Executive Committee of the Corporation approved Dr. Brown's recommendation to dispose of the network analyzer because it had ceased to be a significant factor in the efforts to strengthen graduate research in the power area. The equipment was purchased from M.I.T., and is being installed in the Electrical Engineering Department at the University of Puerto Rico.

A substantial fraction of the faculty who normally would be regarded as communications specialists are enthusiastically participating in the work of establishing the new energy-conversion activities on a high technical plane. The Department also has been greatly aided by the presence of Arnold Tustin of the University of Birmingham as Visiting Webster Professor.

The accomplishment of these achievements creates new problems – one of which pertains to the graduate co-operative Course VI-A, leading to the master of science degree. Students in the regular Course VI program now defer their choice of academic specialization to the senior year. Students in the co-operative course, however, declare their specialization during the sophomore year, because they sign up with a particular company or organization for a three-year period.

A second problem is the responsibility of the Department in its instruction of students from other courses. There appears the need to review and to re-

(*Continued on page 42*)

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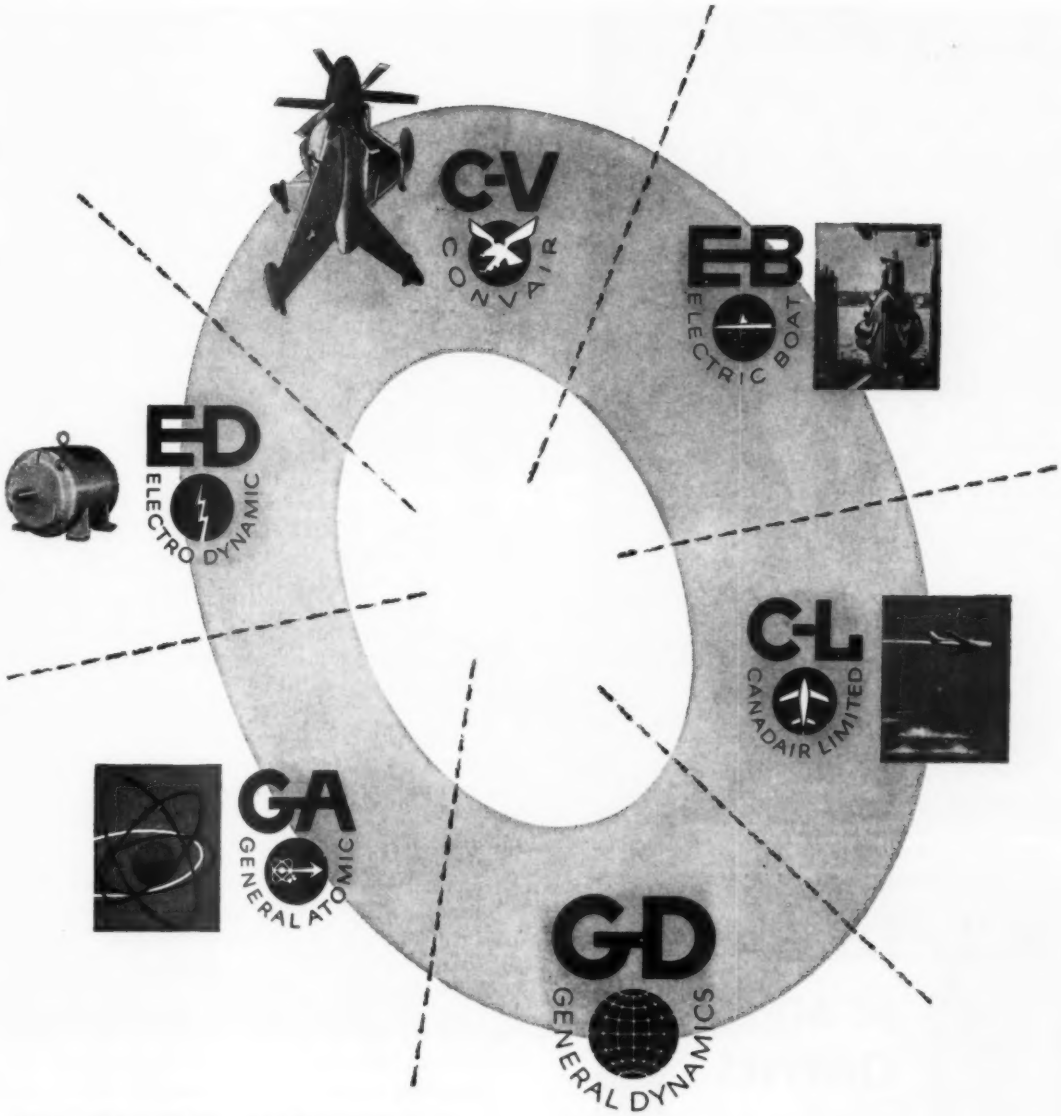

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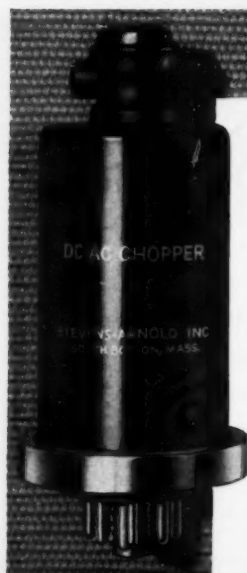

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(*Continued from page 40*)

define in terms of the present-day scientific status of mechanical, chemical, aeronautical engineering – to name merely a few – the needs of these students for knowledge about electrical engineering or electrical science fundamentals. These problems will be given much thought during the coming year.

The Department appears to be vigorous and healthy. The Committee was impressed with the enthusiasm shown by quite a number of staff members and especially with the high educational quality of the work that is being carried on in the various instructional laboratories. The Department's enrollment is about 6 per cent over last year – approximately 1,000 students – with the present freshman and sophomore classes each having about 60 students more than the present senior class [1954]. The graduate enrollment is about 340, and because of the part-time graduate status of junior staff, this registration is about equal to 170 full-time students.

Graduate research is maintaining a healthy pace in all areas, including for the first time for several years, graduate research in the area of energy conversion. Student interest in this important area is definitely on the increase, but the extent of the effort must be scaled up before the Department can claim that its efforts in this area are adequate.

Geological Problems

ASSEMBLING in departmental headquarters on December 6, 1953, the Visiting Committee on the Department of Geology and Geophysics* met with the following members of the Administration to discuss operations and problems of Course XII: James R. Killian, Jr., '26, President; Julius A. Stratton, '23, Provost; George R. Harrison, Dean of the School of Science; and Walter H. Gale, '29, Special Assistant.

Presented below is a summation of the Committee's report which was reviewed at the March 1, 1954, meeting of the M.I.T. Corporation and the April 2, 1954, meeting of the Executive Committee.

(*Concluded on page 44*)

* Members of this Committee for 1953–1954 were: David A. Shepard, '26, chairman, Walter J. Beadle, '17, Cecil H. Green, '23, George J. Leness, '26, Robert H. Winters, '33, E. L. DeGolyer, Hollis D. Hedberg, and Merle A. Tuve.

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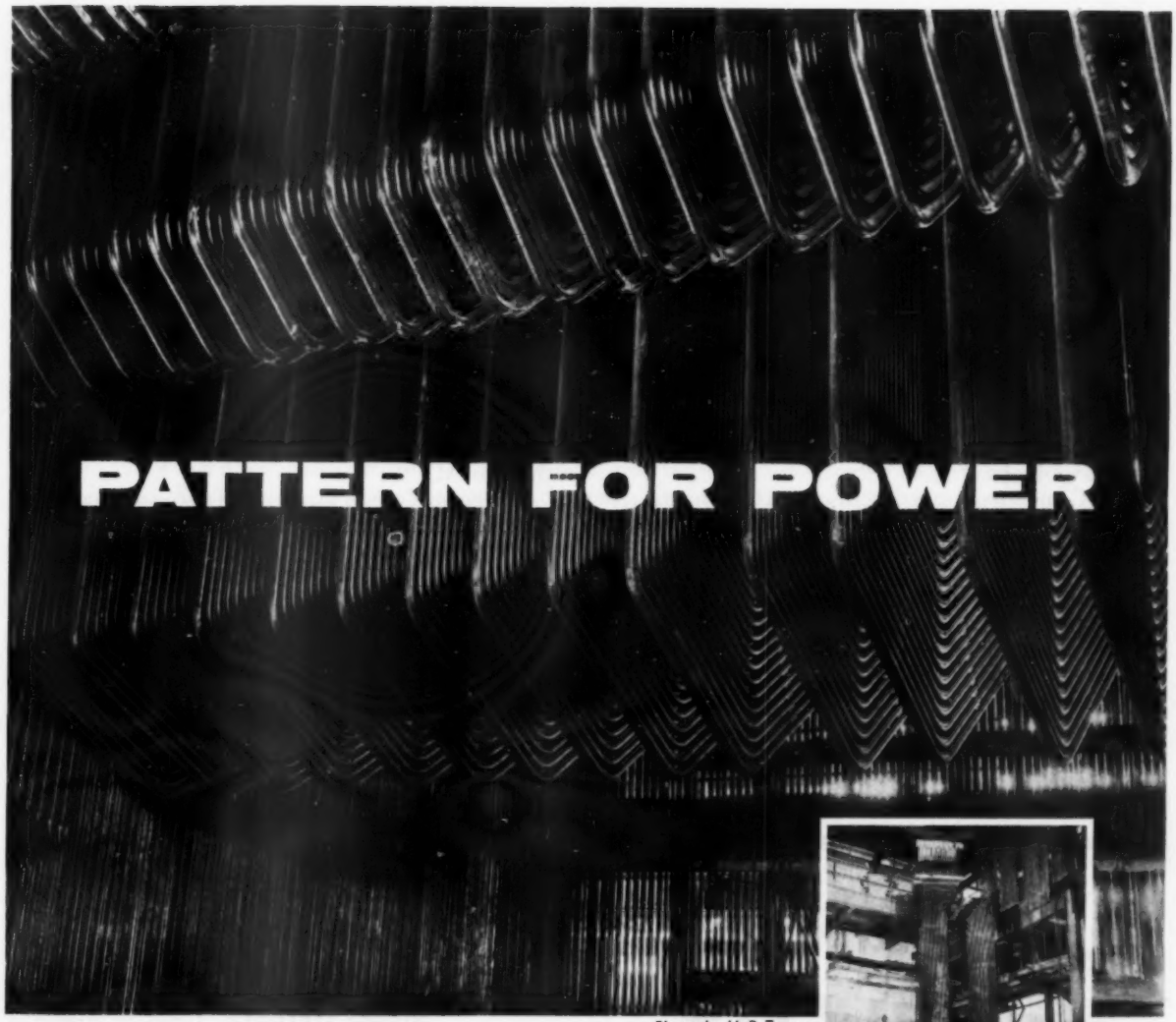
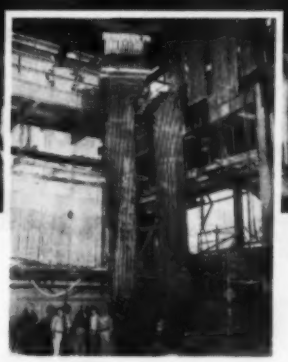


Photos by H. R. Towse



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THE INSTITUTE GAZETTE

(Concluded from page 42)

Professors Robert R. Schrock and Patrick M. Hurley, '40, Head and Executive Officer of the Department, respectively, described the departmental organization, courses of instruction, and the operations and current problems of the Department. A report giving details of the matters presented has been filed with Professor Gale.

In general, the Committee found the Department to be in good condition. It appeared to the Committee that the chairman and the executive officer of the Department had analyzed well the problems to be faced, and with sympathy and help from the Administration, were working toward a sensible handling of those problems.

The Committee's discussion of certain matters studied at the afternoon meeting is summarized very briefly in the following paragraphs:

1. The curriculum offered was discussed with a view to analyzing whether the balance between the quantitative sciences on the one hand, and the geological subjects on the other hand, seemed proper. Aware of rather strong differences of opinion among geologists and geophysicists as to what the proper balance is, it was the feeling of the Committee that the high quality of the basic quantitative science instruction given to freshmen and sophomores at the Institute provided an advantage favoring the current curriculum over alternative ones, including additional geological subjects which could be introduced only at the expense of some of those quantitative science courses. This opinion was supported by belief in the benefits of the summer school in geology at Antigonish, Nova Scotia, and the co-operative plan in exploration seismology.

2. The Committee discussed the Department's difficulties in attracting graduate students with outstanding qualifications in competition with other institutions which can provide more attractive financial inducements. The M.I.T. Department has no fellowships of any kind under its own control, and no unrestricted research funds that can be used to finance students. As a consequence, students who need financial assistance tend to go to a competing institution which can offer such financial inducements, rather than to M.I.T.

3. The size of the Department's student body was considered in relation to the size of its faculty, the Department expense, and the quality of instruction and research by the Department. One suggestion was made that the student body was now somewhat too large, and several of the Committee expressed a more clearly defined opinion that the number of graduate students this year has been too large. Several Committee members felt that a Department of about the present size and staff should be preserved in order to maintain the Institute as one of the leaders in the field of geology and geophysics.

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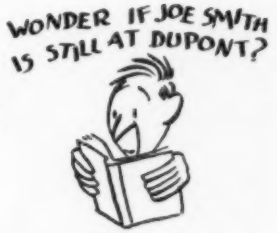

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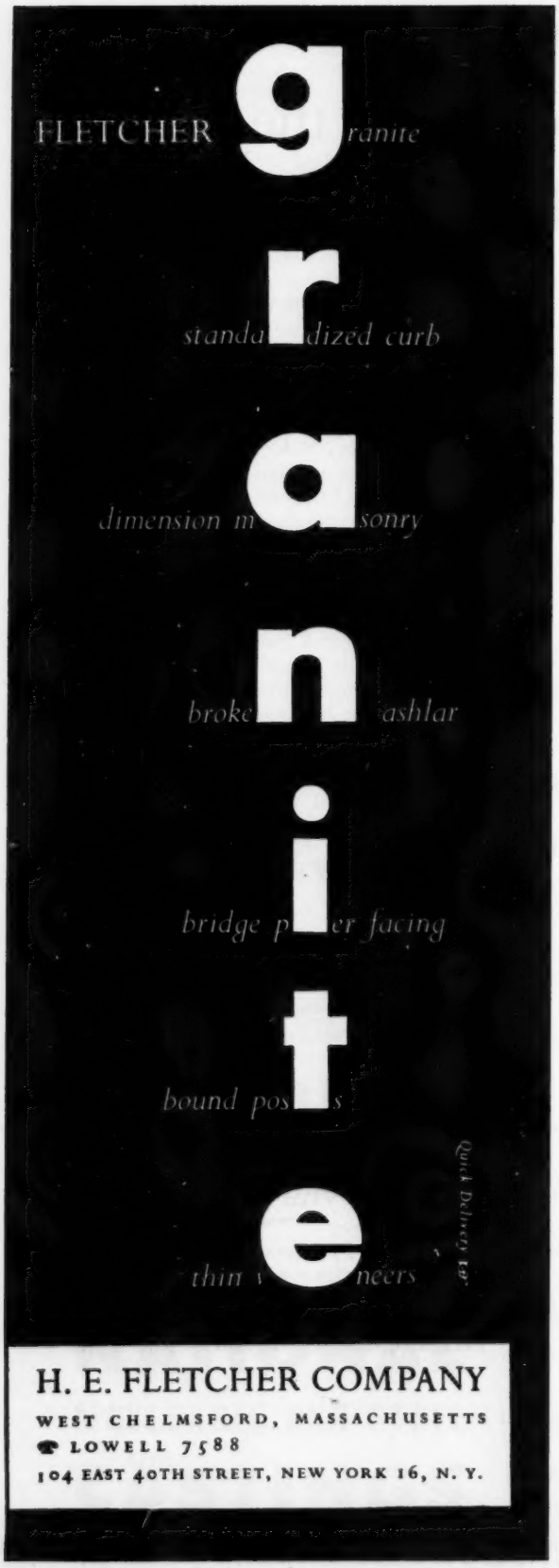

A PLACE FOR GLADNESS

(*Concluded from page 28*)

Well, here is one way that we can spin into our existence activities which yield a conscious satisfaction that may be built to order.

Thrill of Membership in M.I.T.

And now it may be proper to point out that you already have a place for gladness which is always available – which will always be with you and which you may always rely upon to bring a deep sense of satisfaction, of gratification, of inner enjoyment. This resource is your past and present affiliations with this Institute.

During our lifetimes we relate ourselves to many kinds of human institutions toward which we develop varying shades of loyalty and of affection. As you review your affiliations with your Alma Mater I think you will agree that there are few institutions with as fine a record for unselfish and unqualified devotion to the present preparation and future welfare of the human beings in its charge. For many years I have sat in Faculty meetings and in departmental conferences and I have never yet seen an issue discussed in which the progress and advancement of the student or the student body held anything but first position in point of objective.

To march as you do, under such a lifetime banner should, I believe, offer a deep gratification which makes life the richer for you, every year that you are alive.

"They were glad . . ."

Here, then, at this, your 25th reunion, with so much of life behind and before you, you may properly list and appraise these and other satisfactions to make sure that no useful resource has been omitted. And, here I would make one additional suggestion. There can be for each of you a deep sense of elation, of inner joy, when you have built within yourself a sure faith that Someone greater than yourself is always near and ready to help. Within us all there are secret chambers where burns a holy flame, the constant presence of which lifts our hearts whenever we remember.

> "I was glad when they said unto me,
> 'We will go into the house of the Lord.' "

Out of the rich satisfactions springing from our workaday accomplishments; out of the pride and admiration which we hold for those who have "run the good race"; out of an awareness of life's store of loveliness and beauty; out of the enjoyment of endeavor for endeavor's sake; out of the deeper satisfactions from affiliation with the Institute; out of the constant presence of a loving Companion, we may build into our hearts in the days to come, a place for gladness.

Today, gladness is especially uppermost in your heart. Plan, decide, determine, if but for a moment each day, to give gladness a place in your life – tomorrow and tomorrow and tomorrow!

SCIENCE FOR GOOD OF MANKIND

(Continued from page 30)

The auditorium and chapel, now under construction, are the latest additions to new M.I.T. buildings, and a dedicatory program for these new buildings is planned for May 8, 1955. With their completion, the Institute will be in a position to devote greater attention to the spiritual life of its students. Regarding these new buildings, made possible by a grant from the Kresge Foundation, President Killian's report stated, in part:

The small devotional chapel which we are building at M.I.T. . . . will be in the completest sense nonsectarian, equally available to individuals and groups of all faiths. Its purpose is twofold:

First, to stand as a symbol of the place of the spirit in the life of the mind and as a physical statement of the fact that M.I.T. has a right and a responsibility to deal with ideals as well as ideas and to be concerned with the search for virtue while we become proficient in the search for things.

Second, to provide ready opportunity for students and other members of our community to worship as they choose, to have on campus a building, beautiful and evocative of reverence and meditation, where those who wish may enter and worship in their fashion.

This twofold purpose of course includes the provision of opportunities for the separate faiths and groups to use the chapel each in their own way so long as this does not require special privilege. It also means that the chapel will be available for appropriate ceremonies such as marriages and other rites. The chapel will not embrace the full responsibilities of a church and thus will not compete with the neighboring churches which serve members of our community. . . .

The M.I.T. Community

In a section of his report bearing the title above, President Killian took justifiable pride in pointing out some of the highly significant ways in which members of the Institute's Faculty and staff, as well as its Alumni, are making major contributions to public or professional service:

The professional responsibilities assumed by members of our Faculty and staff, and the list of visitors who come to the Institute, constitute together an impressive supplement to the record of the Institute's contributions each year to science and technology. A survey of Faculty and staff activities, for example, suggests that at least 125 positions on national professional boards, panels, and committees were filled by members of this M.I.T. community during the past year. At least 24 major medals and awards for personal achievements came to members of the staff and Faculty during 1953-1954. In addition, more than 30 held elective offices in national professional societies and their local chapters. . . .

Faculty and Administrative Changes

A section of the President's Report dealt with recent changes in the Institute's administrative and educational personnel, many of which have already been reported in the pages of The Review. Significant paragraphs in President Killian's report, which will

(Continued on page 48)

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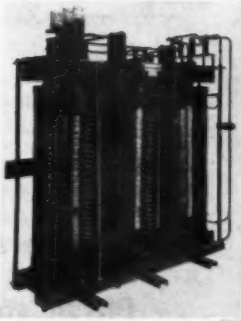

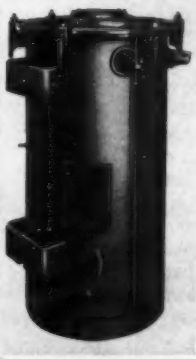

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SCIENCE FOR GOOD OF MANKIND

(Continued from page 47)

bring the reader of The Review up to date on major changes, are given here:

To succeed Admiral Edward L. Cochrane, '20, in the key post of Dean of Engineering, the Institute is most fortunate in securing Professor C. Richard Soderberg, '20, who, as Head of the Department of Mechanical Engineering, has demonstrated outstanding qualities of professional and academic statesmanship. He brings new strength and wisdom to our administrative team. . . .

Other important changes in our administrative organization included the appointment of Robert M. Kimball, '33, as Secretary of the Institute. Mr. Kimball succeeds Professor Walter H. Gale, '29, who asked to be relieved of administrative duties to devote full attention to plans for future development at the Institute. In his new post, Mr. Kimball is working with the Secretary of the Corporation and its committees to further new undertakings of the Institute. He has special responsibility for relationships with the various departmental visiting committees and for the Committee on Development. Professor Gale will also continue a close association with these projects.

Upon the recommendation of Vice-president and Treasurer Joseph J. Snyder, 2–44, Paul V. Cusick and Delbert L. Rhind were appointed assistant treasurers, and Wolcott A. Hokanson was appointed bursar to succeed Mr. Rhind. The Executive Committee approved the establishment of two new posts at the Institute, the Director of Physical Plant and the Director of General Services. Carl M. F. Peterson, '29, has been appointed Director of Physical Plant and R. Colin Maclaurin, a son of our former President, Director of General Services.

Following Professor Soderberg's appointment as Dean of Engineering, Professor James Holt, '19, Executive Officer of the Department of Mechanical Engineering, became acting head; later in the year Professor Jacob P. Den Hartog, who is widely known for studies in applied mechanics, was named to be in charge of the Department.

Other major administrative changes during the year included the appointment of Philip A. Stoddard, '40, as Associate Placement Officer; John W. Sheetz, 3d, '42, to succeed Mr. Stoddard as Assistant to the Director of General Services; Bruce F. Kingsbury, 2-44, as Executive Secretary of the Educational Council; J. Francis Reintjes as Director of the Servomechanisms Laboratory; and George E. Valley, Jr., '35, as Associate Director of the Lincoln Laboratory.

Upon the retirement from active duty of Colonel Charles F. Baish, '21, Colonel Charles M. McAfee, Jr., became head of the Department of Military Science. Dr. Dana L. Farnsworth has resigned as Medical Director, having developed here a vigorous and effective health program for our entire community, and Dr. James H. Means, '06, has become Acting Medical Director. . . .

Unsolved Problems—Unfinished Business

An important problem confronting all colleges is the increasing rate of cancellations on the part of those admitted to study. As against an average shrinkage of 35 per cent for the nation's colleges as a whole, 48 per cent of the students accepted by M.I.T. last year failed to register. One of the principal reasons for the low yield in freshman registration has been the tendency of applicants to apply to more than one institution and then to postpone making a choice until the

(Continued on page 50)

"The day my son's future began"

"Ken knocked around quite a bit after college. Tried several jobs and did well. But he was never really satisfied. He'd either get bored with the work or frustrated with routine advancement. I didn't worry though. He's bright, sensible, and I knew he'd establish himself soon enough.

"Then, about a month ago Ken breezed into my study and somewhat breathlessly announced that he'd decided to go into the life insurance business. Before I could even look surprised, he explained that he had always been interested in people and that this would give him an opportunity to work more closely with them. And his eyes brightened when he pointed out how, as an agent, he'd be his own boss—running a business all his own.

"He went on at a mile-a-minute explaining how he'd be thoroughly trained by New York Life experts—with a good salary while learning. How he figured that once he was on his own he'd be able to give his future family the same kind of comfort and security he had always known at home. And he wound up telling me how, someday, he hoped to retire with a good income—just as I will soon myself.

"Then, quick as he came, Ken up and left without even asking what I thought. But of course he already knew. How could another New York Life agent possibly disagree?"

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SCIENCE FOR GOOD OF MANKIND

(Continued from page 48)

last minute. President Killian also called attention to the growing competition among applicants for scholarship assistance. Although no easy way of meeting these problems is at hand, better counselling in the secondary schools may minimize the seriousness of the first problem. The second problem is being studied by the College Scholarship Service under the sponsorship of the College Entrance Examination Board, with which M.I.T. is co-operating.

Other problems confronting the Institute were also mentioned by Dr. Killian in his annual report:

Corporation visiting committees have made numerous recommendations for expenditures in behalf of academic departments which we have so far been unable to cover. These include $40,000 for the completion of essential equipment in the Hydrodynamics Laboratory, $50,000 for equipment in the Food Technology Laboratories, and $75,000 for equipment in the Metals Processing Laboratory. I have spoken elsewhere of our need for funds to establish a solid program in psychology and "freedom money" to enable members of the staff to do those valuable things which cannot normally be charged to available funds but which will contribute to their professional development.

One of the most critical needs in a specific field at the Institute is for more adequate financing of our Department of Food Technology – a department which is now too dependent upon current funds. Indeed, we have many such enterprises at the Institute which are too dependent on current funds for support. In the immediate years ahead we must seek to secure funds to insure more stability for their activities. This is one of the reasons why I stress year in and year out the need for increased endowment. I do not contend that endowment is the whole answer to our financial problem or that we should seek to be relieved of the responsibility of demonstrating year in and year out that we can justify current support; our problem is, rather, that the Institute in its rapid development during recent years has outgrown even the minimum amount of endowment that it should have to provide the necessary stability and particularly to cover its permanent tenure commitments. . . .

In Conclusion

The concluding paragraphs of President Killian's report to the Corporation state:

These notes on the past and the future of our institution are colored at every point by the catastrophe of Karl

(Concluded on page 52)

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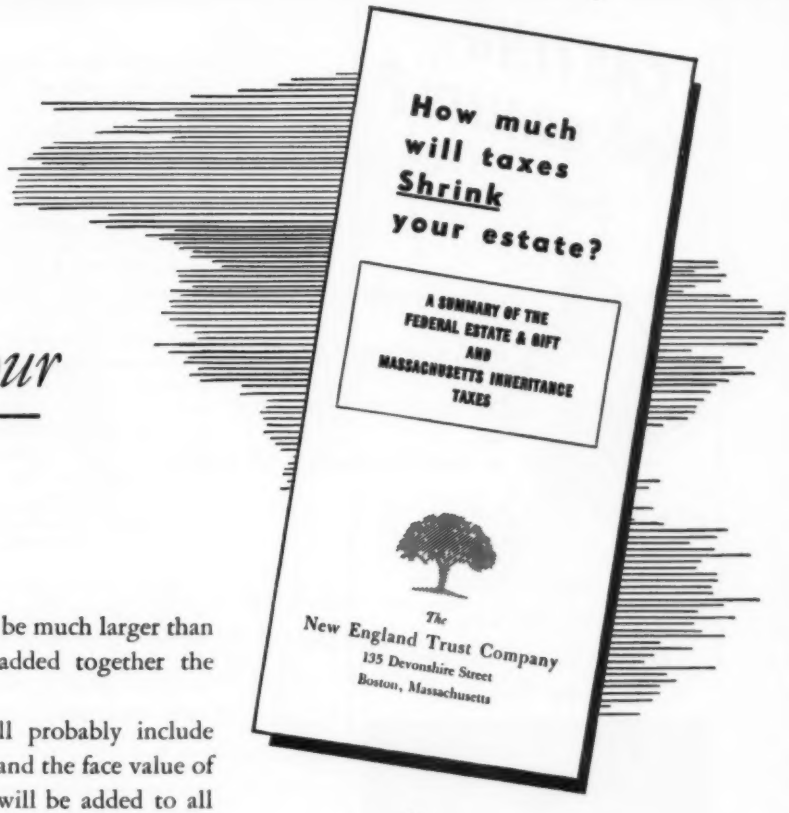
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(Concluded from page 50)

Compton's death. So much of what the Institute means to those who study and work here and to the public, so much about it that is beloved and admired, reflects his influence and his leadership. In contemplating the loss we have suffered we can overcome the deep sense of tragedy only by realizing the permanence of his contributions. The Massachusetts Institute of Technology will always reflect his greatness and each of us who knew and worked with him will have a sense of gladness in having been associated with him. Could he do so, he would be the first to stress the motto inscribed in the marble fireplace in his office: "Alia initia e fine." Thanks to him there will be many new beginnings.

One word more. In all of Karl Compton's career at the Institute and in all that he did for it he was supported and assisted by Mrs. Compton. She too has helped to make this institution a nobler, happier and friendlier place, and the combination of Karl and Margaret was a partnership greater than the sum of its parts. We hope that Mrs. Compton will long maintain her close association with the Institute community, assured that she is beloved and cherished as a member of the Institute's family.

All in all, Dr. Killian's annual message to members of the Corporation of M.I.T. presented a stimulating, thought-provoking analysis of current conditions and future aspirations of the Institute. It differs from similar reports of the past in the extent to which it is concerned with the spiritual side of man's education, in the recognition that study of the physical sciences can be – and at M.I.T. is – a broadening influence, and in the emphasis it places on the need for public recognition of the manifold beneficent uses of science.

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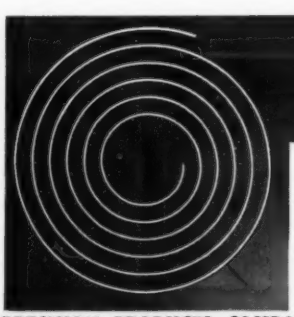

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FRESH WATER FROM THE SEA

(*Continued from page 20*)

narrow channels for the flow of water (see Fig. 5). Salt water is fed into every second passage, whereupon the applied electrical potential causes the positive ions to move out through the negatively charged sheet on one side, and the negative ions to move out through the positively charged sheet on the other side of the salt-water channel. The ions of both types then appear in the second set of water channels and recombine to form salt. The net result is that the water in one set of water channels becomes depleted of salt and purified, while the salt concentration increases in the other set of water channels. The principal need for electric power is to cause motion of the salt ions – almost none is used to neutralize the electric charges on the ions, as in ordinary electrolysis. Because of this, power requirement is reduced.

Ionics, Inc. of Cambridge, Mass., has developed not only the ion-selective membranes but new equipment and processes for their application. Medium-sized units for purifying brackish water have been built and operated successfully, but no large-scale de-salting of sea water has yet been attempted. The process is being continually improved, and it is difficult to predict with assurance the ultimate cost of obtaining fresh water from the sea by this method.

Widely differing estimates have been made for the treatment of sea water by this method. Ellis estimates the total costs for a very large plant to be

(*Continued on page 56*)

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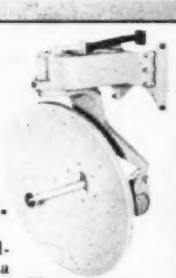

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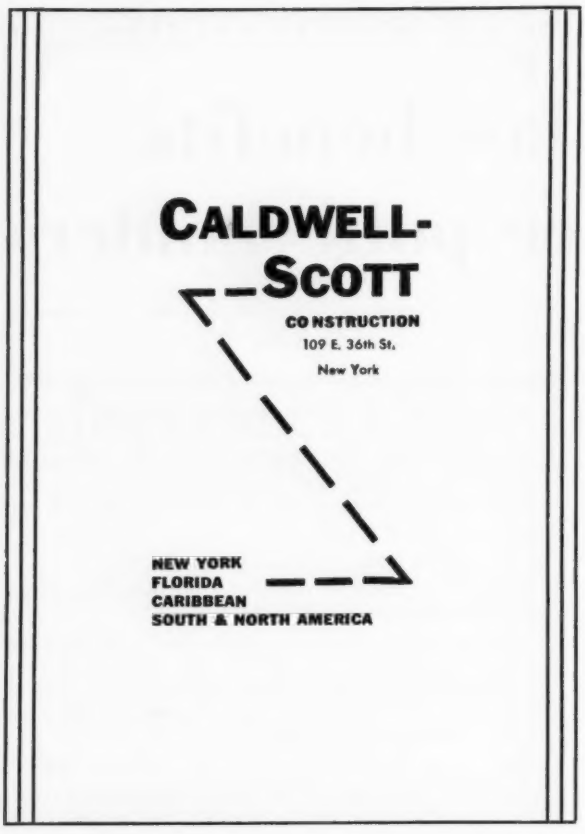

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FRESH WATER FROM THE SEA

(Continued from page 54)

$0.32 per 1,000 gallons fresh water.[8] This is based on a power consumption of 20 kilowatt-hours per 1,000 gallons at 0.5 cent per kilowatt-hour. The estimated power consumption may be optimistic, but the figure of $0.32 for sea water is not much out of line with another estimate of $0.10 per 1,000 gallons for fresh water from Texas brackish water containing 10,000 parts per million of salt (a little less than one third the salt content of sea water). This latter figure, appearing in the 1954 report of the government Saline Water Program,[11] assumes power at 0.3 cent per kilowatt-hour, and lower amortization rates than Ellis. On a basis comparable to Ellis', this figure might become $0.40 starting with sea water. Ionics, Inc., however, is quoted by Representative Arthur L. Miller of Nebraska[5] as estimating the cost of water from sea water at $1.50 per 1,000 gallons using present resin membranes, and $0.40 using "ideal" membranes.

The cost which may reasonably be attained doubtless lies somewhere between these limits – perhaps in the range of $0.75 to $1.00 per 1,000 gallons. If so, the process is evidently the cheapest of any which have been operated on a commercial scale for the production of fresh water from sea water.

Other Methods

Literally dozens of physical phenomena may be employed as the basis for separating water and salt, and there are hundreds of patents relating to the production of fresh water from the sea. Some involve gravity effects, with or without the help of electricity, using either natural gravity or a centrifuge. One patent proposes that sea water be heated to a high temperature at several thousand pounds pressure under which conditions distillation may be accomplished without supplying any heat of vaporization. Solid adsorbents have been proposed, although it might seem more difficult to remove the salt or water from the adsorbent than from the original sea water. Experiments have been made with thermal diffusion, the process employed on an experimental scale for the separation of uranium isotopes. This scheme proved too expensive for the Manhattan District, so would appear to be impractical for cheap water. Other proposals involve the use of ultrasonics, ultra high-frequency electrical energy, streaming potentials, electrostatic and electromagnetic effects.

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The high cost of getting fresh water from the sea by known and developed processes is discouraging, and the obstacle in the way of progress towards really cheap water is the lack of good new ideas. In this situation the government has wisely allocated a modest amount of money to support research on new processes, with the idea that government support of an inventor's concept in the early stages of its development may carry it to the point where commercial development is warranted. These research grants are administered by the Saline Water Conversion Program of the Department of the Interior. The availability of funds and publicity[4] regarding the problem have already stimulated a number of new and promising ideas, though the program has been under way less than two years.

One of these government-supported research studies[11] is giving a new look at an old idea – that pure water can literally be pushed out of salt water by forcing it through membranes permeable to water but not to salt. Such membranes exist, and the use of one of the many new plastics may make the scheme practical. The idea is to reverse the familiar laboratory demonstration of osmosis (see Fig. 6). A bulb covered with a porous membrane is attached to the end of a long open tube containing salt solution, and the bulb end of the tube is dipped into pure water. The water is found to pass into the salt solution in the tube, and the flow does not stop until the level of the solution in the tube rises many feet above that of the water into which the tube is dipped. The hydrostatic pressure of the column of solution is the osmotic pressure, which for sea water is 350-400 pounds per square inch. The process can be reversed by applying pressure to the open top end of the tube, and water forced out of the solution. The solution in the tube then becomes more concentrated, since the salt cannot get through the membrane coating the porous bulb.

The theoretical minimum power to pump the water through the membrane is 2.8 kilowatt-hours per 1,000 gallons, as for all other processes. The actual power must be greater in order to obtain reasonable rates of passage of water through the membrane, and the possibility of low actual power costs competitive with other processes will depend on the development of membranes which are not now known. Chances of success are not great, but the idea is sound.

It is a sad commentary on the state of science that we do not know how to perform the common operation of separating a salt from water without using

(*Continued on page 58*)

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FRESH WATER FROM THE SEA

(*Continued from page 57*)

several times the theoretical minimum power. If the research on methods of purifying sea water leads to improvements in this situation the results will find wide application in many industrial processes.

Summary of Costs

Although cost figures for producing fresh water from the sea have been suggested for several of the principal processes, it must be admitted that these are little better than rough estimates. Published cost figures for these processes are based on widely varying costs for power and amortization, and the basis for each estimate must be scrutinized before the result can have meaning. The figures listed in the following table are based on power at 0.5 cent per kilowatt-hour, steam at $0.60 per 1,000 pounds, and fixed charges at 15 per cent per year:

	Total Cost $ per 1,000 Gallons
Simple distillation	5.00–10.00
Multiple effect distillation	3.80
Vapor-compression distillation	1.70
Solar distillation	2.85
Freezing	0.75–1.25
Chemical precipitation	30.00
Ion-exchange resins	20.00
Ion permeable resin membranes	0.75–1.00

The estimates for simple distillation, ion exchange, and chemical precipitation do not have to be close, since the costs are prohibitive on any basis. The estimates for multiple effect distillation and vapor compression distillation are fairly reliable (probably within 25 per cent) since these processes have been used on a large scale. The figure for solar distillation is probably low on the basis of present costs of collectors, but new collector designs might change this picture somewhat. The cost for the freezing process is only a very rough guess and is doubtless low, since the method has never been employed on a commercial scale. The estimate for the resin membrane method may be off by 30 per cent, but is close enough to suggest that this is one of the cheapest of presently developed methods.

(*Concluded on page 60*)

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FRESH WATER FROM THE SEA

(Concluded from page 58)

Conclusion

In the earlier discussion two cost targets were suggested: the figure of $0.084 per 1,000 gallons of fresh water, which might be considered as the ultimate and quite nebulous possibility, and the figure of $0.40 per thousand, which is about the top figure which communities now pay. Estimated costs of the resin-membrane and vapor-compression distillation processes are within two to fourfold of the second target where sea water is used, and the resin membrane method can probably meet the $0.40 figure in producing fresh water from many types of western brackish water.

As the water situation gets progressively worse, water from sea water can be made available at prices which many users will be willing to pay. Processes exist for the alleviation of serious water shortages, albeit the investment in plant will be very large.

The situation in regard to irrigation water is quite different. The average value of the crops produced on irrigated land is estimated to be only $0.10 per 1,000 gallons of water used,[10] so it seems evident that even if the ultimate target of $0.084 per 1,000 gallons were reached, and this appears highly unlikely, fresh water from the sea will not be used for irrigation of the average crop.

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(*Concluded from page 22*)

a leading authority, by a regimen throughout life which maintains good circulation through regular exercise, by the avoidance of dangerous obesity, and by the prophylaxis and proper treatment of infections of the bronchi and lungs and asthmatic conditions. Physical activity is desirable and necessary for persons of all ages, including the elderly, but it should, of course, be sensibly adapted to the age and physical capacity of the individual. A person 50 or 60 obviously cannot and should not participate in the same type of strenuous physical activity that may be appropriate for a person of 20 or 30. Necessary indulgence in exercise may be one of the reasons why the rural population tends to remain healthier and live longer than the more sedentary and more excitable urban population.

Another potent procedure in the endeavor to defer the encroachment of baleful old age is the annual physical examination. If everyone would adopt the salutary custom of going to a competent physician at least once every year for a complete medical overhaul, or physical appraisal, minor defects and troubles could be detected and corrected before they have the opportunity to become serious. Experience has shown that practically nobody over the age of 40 will be found in a state of perfect health, although some patients may approach it. The annual health examination, if properly conducted and adequately followed up, makes a real and substantial contribution to personal and public health.

As pointed out in a previous article,‡ the United States is rapidly becoming a nation of older people. More than 8 per cent of our population, or about 13.4 million persons were aged 65 or over in 1953, and of these somewhat more than one third were 75 or more. The enrichment of old age in this country is, therefore, a matter of great sociological and economic, as well as medical and biological significance. At least one fifth of the men and one half of the women who have now attained 65 years may expect to survive beyond the age of 80.

"Grow old along with me!" wrote Robert Browning in his *Rabbi Ben Ezra*, "The best is yet to be, the last of life, for which the first was made." Old age is an interlude in life which can be, and should be reasonably productive, gracious, and salubrious.

‡ Tobey, James A., "Is There a Limit to Human Life?" Technology Review, **56**:349 (May, 1954).

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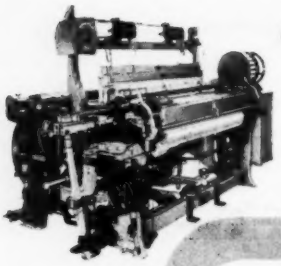
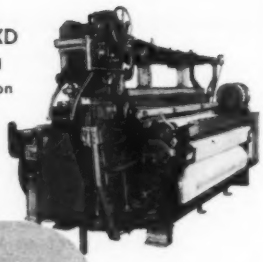


Model X-2

Model XD
with 2X1
Box Motion



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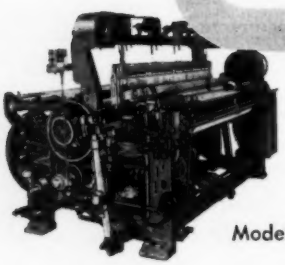
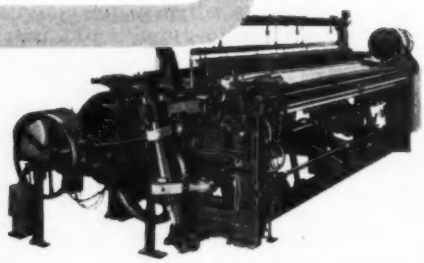


Model XP

Model XL



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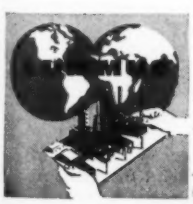

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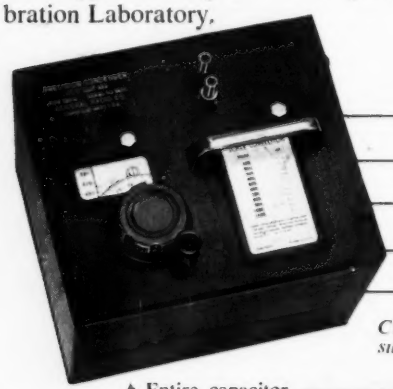

Type	Range Direct Reading ($\mu\mu f$)	Accuracy of Reading: Direct Reading	Accuracy of Reading: With Correction Chart Supplied	Accuracy of Reading: With Worm Calibration (Additional Cost)
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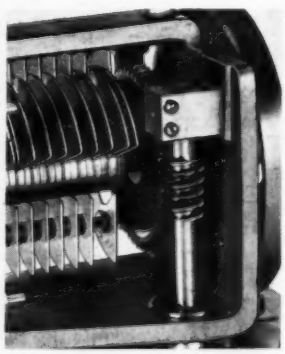
$205	25 to 115	±0.1% ±0.2 $\mu\mu f$	±0.1% or ±0.08 $\mu\mu f$*	±0.1% or ±0.02 $\mu\mu f$*
722-MD	0 to 1050	±0.1% ±1 $\mu\mu f$	±0.1% or ±0.4 $\mu\mu f$*	±0.1% or ±0.1 $\mu\mu f$*
$205	0 to 105	±0.1% ±0.2 $\mu\mu f$	±0.1% or ±0.08 $\mu\mu f$*	±0.1% or ±0.02 $\mu\mu f$*
722-ME	0 to 105	±0.1% ±0.2 $\mu\mu f$	±0.1% or ±0.08 $\mu\mu f$*	±0.1% or ±0.02 $\mu\mu f$*
$205	0 to 10.5	±0.1% ±0.05 $\mu\mu f$	±0.1% or ±0.02 $\mu\mu f$*	±0.1% or ±0.005 $\mu\mu f$*
722-N $180	100 to 1100	±0.1% ±1 $\mu\mu f$	±0.1% or ±0.4 $\mu\mu f$*	±0.1% or ±0.1 $\mu\mu f$*

*whichever is greater

Changes in construction or added mechanical features will be supplied on special order to suit customer's particular requirements. WRITE FOR COMPLETE INFORMATION.

↑ Entire capacitor is mounted in a carefully-tooled cast frame for maximum rigidity. Key areas are milled to close tolerances to insure minimum strain on capacitor plates when assembled in the casting.

The frame, plates, stator rods and spacers, and the rotor shaft are all made of the best available alloys of aluminum; all parts have same temperature coefficient of expansion. Bars of low-loss steatite support the stator assemblies, and polystyrene bushings insulate the terminals from the panel. Quartz insulation will be supplied on special order.



← A worm drive is used to obtain the desired precision of setting. To avoid "play", the worm is actually cut right in the shaft. Bearing diameters are held to within ±0.0002 inch. The dial end of the worm shaft runs in high quality, self-aligning ball bearings; the other end is supported by an adjustable spring mounting. Radial eccentricity of the worm gear is less than 0.002 inch. Electrical connection to the rotor is made by means of a spring-silver brush running on a silver-overlay drum to assure positive electrical contact.

Type 722 Precision Capacitor is calibrated on G-R's standard calibrating equipment. The unit is artificially aged at elevated temperatures to stabilize mechanical structure.

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